MODERN SCIENCE AND MATERIALISM

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PREFACE

The preparation of this book has involved a study of many different branches of Science and Philosophy. As I completed my survey of these various branches in turn, I usually summed up the conclusions which I had gathered and published them as articles in the reviews, with the object partly of giving precision to the ideas, partly ot gaining the advantage of criticism. It thus comes about that I have to make a number of acknowledgments for permission accorded me to republish parts of these articles in the present work. The greater part of Chapter I was published in the *Candid Quarterly Review* for November 1916. Certain portions of Chapter III appeared in the *Edinburgh Review* for January 1909, January 1911, and April 1912. Part of Chapter IV was published in *Science Progress* for January 1915. The theory of Chapter V was sketched in two articles in the *Hibbert Journal* in April and July 1916. Finally, a small part of Chapter VI, and many of the ideas of Chapter IV, were developed in articles in *Bedrock* in October 1912, July 1913, and January 1914. To the proprietors of these Reviews I tender my cordial thanks for their courtesy in allowing me to make use of these articles for the present work.

I have also to thank Mr. Mark Barr for many valuable observations and criticisms on Chapter II.

H. E.

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INTRODUCTION

In all ages since the dawn of civilization, inquiring minds have been enthralled by certain fundamental questions, which are felt to be of greater magnitude and importance than any of those matters of detail which confront us in the ordinary course of our daily lives. What are we? whence have we come? whither are we going? what was the object of the Universe? and what will be its end, if it ever have an end?—questions such as these have oppressed all the greatest thinkers of history; they have perplexed to some extent nearly all men, save those whose mental horizon is limited to the immediate satisfaction of their material wants.

Yet, after more than two thousand years of civilization, not one of these questions has advanced in the smallest degree towards a solution. There has, indeed, been no lack of speculation or of theories which for a time were believed to be solutions. Innumerable systems of mythology, systems of religion, systems of philosophy, innumerable superstitions, too crude and incomplete to be called systems, have risen at different times and places, have secured the allegiance of tribes, nations, and races, have risen and flourished for a time, then crumbled away and lost all interest except to the archæologist and historian. The greatest and most learned minds in the annals of mankind have worn themselves out over these problems, and still made no step towards an answer. Yet they continue to weigh upon thoughtful minds with undiminished force. Moreover, there is a general recognition of their fundamental importance for humanity. Religion occupies a pre-eminent position in human affairs. It is regarded as apart from and above other things. This fact alone is sufficient evidence how deeply the human mind is impressed by the ultimate mysteries of existence.

Although the desire for knowledge of this kind is so imperative in man's nature, all attempts to satisfy it have failed. It is clear at the outset, therefore, that the subject itself is outside the range of human intellect. If a solution ever could have been found, it would assuredly have been found before now. Philosophy cannot furnish answers to these ultimate questions; it can, however, do something towards allaying unsatisfied curiosity, partly by making clear what branches of inquiry are necessarily outside the scope of human intellect, partly by setting forth the things that we *can* know in an organized and systematic form. Philosophy can do no more than this: mark off the sphere of possible knowledge from the sphere where knowledge is impossible; then collect together the main principles that emerge in the knowledge at present possessed by mankind; and thereby we shall, at all events, perceive to the highest extent possible where it is that we stand in Nature, and what is the general aspect of the Universe.

Let us first ask why it is that all past efforts to solve ultimate riddles have failed, and why it is that they must continue to fail. It is, in the first place, due to the fact that all knowledge is based on sense-impressions, and cannot, therefore, go beyond what the senses can perceive. Men have five or six different senses only, and these are all founded on the one original sense of touch. Of these five or six senses, the three of most importance for the accumulation of knowledge are those of sight, hearing, and touch. By these senses we are able to detect three separate qualities of the external Universe. Now, supposing that we happened to have a thousand senses instead of five, it is clear that our conception of the Universe would be extremely different from what it now is. We cannot assume that the Universe has only five qualities because we have only five senses. We must assume, on the contrary, that the number of its qualities may be infinite, and that the more senses we had, the more we should discover about it.

Not only are our senses few, but they are extremely limited in their range. The sense of sight can detect nothing but waves in æther; all sensations of light and colour are no more than æthereal waves striking upon the retina with varying strength and frequency. And even then, it is only special æthereal undulations that give rise to the sensation of sight. The majority cannot be perceived by the retina at all; it is only when the waves follow one another within certain limits of rapidity (between four hundred billion and seven hundred billion a second) that sight ensues. If the waves are below the lower limit of rapidity, they do not give rise to the sensation of light at all, though they may give rise to a sensation of heat. If they are more rapid than the higher limit (as in the case of ultra-violet rays) they are not discernible by any sense at all.

The sense of sound, similarly, is caused by vibrations of the air; but if the vibrations pass a certain limit of rapidity (about thirty-eight thousand a second) nothing whatever is heard. In the same way, the sense of touch cannot detect a very light contact, and is crushed by a very heavy one. All the senses thus operate only within a very narrow range; that upon which we most rely—namely, sight—tells us nothing more than the existence of certain waves in æther following one another at certain intervals, and this small piece of knowledge is surely next to nothing, when we are endeavouring to understand the ultimate realities of life and existence.

Thus all our knowledge of the Universe is based on sense-impressions; nor can we so much as imagine or conceive of anything that is beyond the sphere of our senses. We can, indeed, become aware of many things outside the range of sense by means of reasoning. We cannot see that the Earth is spherical, but we can infer it. The æther of space makes no impression on our senses, and its more rapid vibrations cannot be perceived. Yet we can easily understand that they exist, and in our "mind's eye" see the ultra-violet rays which our bodily eye is blind to. We are still working in terms of vision, even though it is imaginative and not actual vision. The same truth applies to our most transcendental efforts of imagination. Take, for instance, the religious conception of an after-life. If we imagine it at all, it must be in terms of sense-impression, otherwise nothing remains: if we exclude sense-impression we have nothing but total darkness, total silence, total anæsthesia, no taste, smell, or pressure, no feeling of motion. Yet we do not conceive of an after-life in this manner, as though we should be blind, deaf, and paralyzed. We conceive of it, if at all, in terms of light, sound, motion, however vaguely. Even here our imaginations are limited by the range of our present senses.

If, then, all knowledge and all imagination is based on sense-impressions, it is clear that our notion of the Universe is bound to remain for ever of the most incomplete possible character. Supposing we had a few more senses, how very different everything would appear! Supposing we had a hundred more or a thousand more, the Universe must appear different from anything now conceivable. To a being thus endowed, the philosophy of a mere human being must appear indeed primitive. His understanding would exceed ours by far more than ours exceeds that of a sea-anemone washed by the waves and drawing within its tentacles whatever edible morsel happens to float by. Yet, though it would so vastly exceed ours, the intellect of even this being would be no nearer than *we* are to the ultimate mysteries of existence. For if the Universe cannot be understood by one who perceives only five or six of its modes of working, we can hardly suppose that its secrets would be delivered up if we knew a hundred or a thousand of its modes. A still more exalted being, possessing a million senses, would far surpass one with a thousand; but to understand the ultimate nature of the Universe, we should require not a thousand, nor a million senses, not a finite number of senses at all, but an infinite number; for so long as we have anything less than an infinite number of senses, there must always remain unknown aspects of the Universe, which might be disclosed by the possession of further senses. It follows plainly enough that ultimate mysteries are not soluble by us, and that attempts to solve them arise only from a total misconception of the nature of the problems at issue We are forced at the outset to adopt the position of Agnosticism.

Let us be clear what we mean by this name of Agnosticism, for the word has been bandied about so much in public controversy that, as generally occurs with words in common use, its meaning has become vague and ill-defined. Last century it was employed largely as the converse of theism. In opposition to those who affirmed the existence of a God, there arose a school, calling themselves Agnostics, who, without denying this existence, took the view that it was impossible to say whether or not a God exists. This school, moreover, was apt to assume that Agnosticism was the final goal of philosophy, and thereafter that nothing more remained to be said. The Agnosticism of this school is very different from that which we are now about to adopt. In the first place, it is far more limited in scope. The question of the existence or non-existence of a God is an isolated single question, to which the new Agnosticism pays little attention, and which it even repudiates altogether. For it is not necessarily an unanswerable question; it is, perhaps, even relatively easy to answer. The earlier Agnostics themselves very often answered it by implication, for their general attitude was such as to suggest a definite disbelief in the existence of a God. The new Agnosticism does not touch this particular question; it refers only to the impossibility of reaching *any* solution of ultimate mysteries by *any* theory whatsoever.

Still more incorrect is it to regard Agnosticism as the final goal of philosophy. So far from being the end, it is the actual beginning of knowledge. We have to start with it as an axiom; and, having studied it, and recognized all its implications, we have to go on and establish our philosophy afresh within the limits set by our initial Agnosticism. The discovery of Agnosticism—the discovery of our ignorance, that is to say—though not the end of philosophy, is a most important landmark in the history of philosophy. The position prior to this discovery was, not only that men were ignorant, but that they were ignorant of their own ignorance. They knew no more than we do what is the ultimate origin or destiny of the Universe, but they thought they knew; indeed, so certain were they of their own knowledge, that they have often meted out abuse and persecution to those who questioned it. For, be it noted, a conscious belief in one's own ignorance implies a considerable advance of civilization. The original state of man was one of the most violent and irrational convictions. The belief in after-life was so implicit, that women would cast themselves on their husband's funeral pyre to rejoin them immediately after death; that money-lenders would advance money on note of hand payable in the next world. As civilization progresses, the intensity of irrational conviction declines, while the intensity of rational conviction correspondingly increases. Knowledge grows and pseudo-knowledge dwindles, till men begin to question the basis of their beliefs, and finally formulate the theory of Agnosticism to destroy the last remnants of pseudo-knowledge or superstition. Agnosticism is thus a clearance of the mental rubbish handed down to us from the past, and preserved by the infirmity of our own minds. The era of Agnosticism marks the point in the history of philosophy at which our minds are swept clean, and rendered suitable repositories for genuine knowledge. The mental progress of mankind is thus not from conviction to scepticism or vice versa. The beginning and the end of progress are equally characterized by strong conviction. At the beginning it is the conviction of bigotry and superstition; at the end it is the conviction of science. Between these two termini the bridge of Agnosticism has necessarily to be traversed—the great discovery by mankind of their own ignorance in presence of the immeasurable complexity of their environment.

It is not the purpose of the present work to furnish a defence of the Agnostic position. That task was sufficiently carried out by the writers of last century, and in my work *Modern Science and the Illusions of Professor Bergson* I said all that seemed necessary in destruction of metaphysical pseudo-knowledge. The purpose of the present book is not destructive but constructive. If we take our start from Agnosticism, it means no more than that we embark on our inquiries with minds free from the encumbrance of superstition. We start then, as every scientific investigation ought to be started, from an Agnostic position; and the first question that arises is, what kind of philosophy we can construct within the limits drawn for us by Agnosticism. In other words, what sort of philosophy can be founded on the present knowledge attained by man? Naturally such a philosophy must be far less ambitious than the metaphysics of those who are not bound to the solid earth, but are free to soar wherever their imagination can penetrate. *Our* philosophy, on the other hand, must be strictly based on facts, and capable of verification by direct observation or experiment. Its progress is wholly dependent on the knowledge of the times. As that knowledge increases, true philosophy can likewise expand; and in times of ignorance no true philosophy is possible. We have expressly abandoned all attempts to understand the ultimate nature of things; nevertheless, the present state of human knowledge is sufficient to permit the emergence of certain fundamental principles of profound philosophic import. It is the purpose of the present book to collect together and present these all-embracing principles, and to show that they constitute on the one hand a materialistic system, and on the other hand an idealistic system, according to which way we look at them, and to whether we employ the objective or the subjective method.

Since our philosophy is to be built upon facts—upon the knowledge possessed by men at the present time—the first task of this book must be to review that knowledge, not, of course, with any thought of exhaustiveness, but in order to indicate the general scope and nature of the facts known to mankind, upon which philosophy must necessarily be based. A philosophic principle is one that embraces a vast multitude of facts; moreover, such a principle is immediately upset by the discovery of any single fact which conflicts with it. It is true, no doubt, that most of the great generalizations of science, such, for instance, as the Law of Gravitation [1] and the first two Laws of Thermodynamics, are so solidly established that the discovery of any contradictory fact is scarcely conceivable. Any such alleged discovery would suggest only error or illusion on the part of the discoverer. Thus it happens that these great principles, which may rightly be called philosophic, are based upon a stronger foundation of certainty than *any* single fact can claim. They are based on long and universal experience, which confers upon them as high a degree of certainty as can be attained by humanity.

[1] Without prejudice to the Principle of Relativity. As to how far Newton's Laws may be an absolute and final expression of the facts, is a question I do not raise.

Now human knowledge is systematized and embodied under the name of science. To science, therefore, we must look as the foundation of our philosophy. But science as a whole is divided up into a number of separate sciences, each of which is studied by a different kind of worker. This division is made for the practical convenience of study; it does not correspond to any actual divisions of natural phenomena. Nature is a whole, not broken up into separate compartments; and to obtain a true idea of the knowledge of our times, we must disregard the limits of the special sciences, and survey Nature as a whole; thus only can we know where modern knowledge has carried us in helping us to perceive where we now stand with reference to the great problems of philosophy.

In making such a survey, our outlook is indeed very different from that of the common man who sees around him only those things which have an immediate interest for himself. We, on the other hand, must suppress our own individuality, and look at Nature, not as though we ourselves were the centre of it, but as it has been disclosed by the culture of the various sciences: we must look at Nature from the utterly disinterested standpoint of an outside observer, and with an eye of transcendent power; for this philosophic eye is served on the one hand with the most powerful telescopes of astronomy, and on the other hand with the most powerful microscopes of modern science. We are thus no longer limited to seeing objects of a size commensurable with ours; our range of vision is mightily extended, and the things which we shall see are vastly different from those which appear to the unaided and self-centred vision of the common man.

When we thus look out on Nature with a philosophic eye, what is it that we behold? The Universe is made up of vast aggregates of matter, moving about in various directions, emitting light and heat, and displaying other physical manifestations. Nothing, we notice, appears to be still; while we look, there is no single particle of matter that has remained in the same position with regard to other particles, nor, out of the great aggregates of matter composing the various stars and nebulæ, is there any which remains even for a moment just exactly what or where it was. In other words, we see that all things are in a state of change or flux; nothing remains unaltered for an instant. It is a moving and changing Universe with which we have to do.

In the next place, all that we behold may, as a first step, be classified into two or three categories of phenomena. Firstly (pending further analysis), there is what we call *matter*. This comprises all the *objects* which we discern. Then there are motion, heat, light, sound, electricity, etc., etc., which are not matter, but which are all related to one another, and constitute one fundamental phenomenon; this we call *energy*. As we look further, we may think we see a third type of manifestation, which cannot be brought under the heading of either matter or energy. This third type we call life and mind. As regards life, indeed, we perceive it only on one insignificant portion of matter, namely, the Earth; and our eye is not yet sufficiently developed to inform us by direct vision whether it occurs elsewhere. As regards mind, we are still more circumscribed, for we know it directly only in our own person, and the perception of it elsewhere is no more than a matter of inference.

Leaving aside for the moment this third category of life and mind, we find, then, that the Universe consists of matter and energy in a state of permanent change. We perceive, moreover, that the whole course of that change is not haphazard, but that it follows certain fixed sequences—usually called laws—which are so definite that even in the present state of knowledge many future events can be prophesied with certainty; and that, if our knowledge was unlimited, *all* future events could be so prophesied.

All human knowledge is derived by observation and experiment. The facts thus made known are co-ordinated or systematized in the various sciences. They are the individual bricks out of which the edifice of a scientific theory is built. As isolated facts, they have little philosophic import; but in proportion as they can be co-ordinated into broad generalizations, they take on a deeper philosophic significance. Science, therefore, alone can furnish the data of philosophy. If there is any knowledge attainable that can truly be called philosophic, it is such knowledge only as is yielded by a study of the various sciences. Consequently, the first thing to be done in any search after philosophic principles is to travel over the special sciences with a view to extracting from them such information as is relevant to our purpose.

Stated differently, the problems usually comprised under the name of philosophy are those dealing with the great questions of profound human interest: what is man's place in the Universe? whether there is any transcendental purpose inherent in the eternal drifting of matter and energy? and so on. The answer—in so far as any answer is possible—to these ultimate questions must plainly be reached by marshalling together such information as we already possess concerning the Universe. The primitive mind has a small knowledge of real facts, and upon this narrow basis erects a vast fabric of mythology or ontology. The more developed mind has a larger knowledge of real facts; and upon this broader basis erects a far less ambitious superstructure of philosophy. Before we can discern the deeper relationships of existence and the Universe, we must know all that can be known about these ultimate facts. That is a task far transcending the powers of any single mind; nevertheless, if we limit our endeavour to the establishment of a few general principles, it does become possible to test them by application to the different branches of natural science. We must, then, begin by reviewing the scientific knowledge of our times—

not, of course, with the smallest pretension to completeness —but with a view to extracting all such information as bears upon the principles we propose to establish. The first four chapters of this book are devoted to that task; the two final chapters endeavour to present the philosophical conclusions that emerge from this study.

Chapter I deals with the material structure of the Universe, in so far as it can be seen by powerful telescopes or inferred from observations made with such telescopes. We clearly have to begin with some account of the general distribution of matter throughout the Universe on the largest imaginable scale.

Chapter II deals with the constitution of matter itself, and some of the main laws of matter and energy. The magnitudes we have here to deal with are infinitely small—small beyond the wildest dreams of fancy. From these two chapters alone we already get a broader basis for philosophic generalization. The first deals with magnitudes so great as to be for ever beyond the remotest possibility of imagination; the second with magnitudes so small as equally to defy the most transcendent powers of description.

Chapter III deals with life and consciousness, in which the magnitudes are those recognized in our ordinary life. But we find that in another way the strain upon our imagination rivals that to which we are subjected in the spheres of Astronomy and of Physics. It is no longer by magnitude that we are oppressed and baffled. It is by complexity and variability. For there is no dividing line between organic and inorganic. A living plant or animal is a portion of matter with contained energy, in no way different in principle from an inorganic compound. The difference merely lies in the inconceivable complexity of its constitution. Here, therefore, we are introduced to a third sphere, in which the truths of Nature transcend to an infinite extent the most boundless imagination. It is hard to say in which sphere we are most completely paralyzed—whether in the contemplation of infinite greatness, or of infinite smallness, or of infinite complexity.

Nevertheless, we have already greatly enlarged our outlook upon Nature. The Universe is wonderfully different from that little world in which we pass our commonplace lives. In whatever direction we look out, we are quickly carried away beyond the bounds of our feeble imaginative faculties. And if, in whatever direction we look, and however far we go, we find the *same* principles at work everywhere, then we are justified in stating those principles as the elements of philosophic truth. We *can* find no more; they are the limit of what a man can know.

Chapter IV deals with the relation of consciousness to the nervous system, and is a prelude to the general discussion in Chapter VI as to the relations of mind and matter. For all thought and all intellect appear to us as *mental* in texture, by strong contrast to things that are *material* in texture. Yet the process of conscious life within the organism is altogether dependent on the material processes occurring within its brain and nervous system. In any discussion as to the nature of mind, the first thing to be done, therefore, is to collect together every shred of information furnished by physiology as to the general trend of the nervous phenomena underlying consciousness. Woefully incomplete as our information still remains, certain large truths do emerge; and they are sufficient for our purpose. Physiology has already attained results of cardinal importance to philosophy. We must hold fast to that solid rock in entering the dangerous quagmire of metaphysics; and if we do, we shall find we do not sink. In treating subjects hitherto relegated to metaphysics, we have at length this immovable rock established by physiology. If we anchor ourselves firmly to it, and accept whatever conclusions we are thereby forced to accept, we shall indeed come across much that is startling and unfamiliar—much that disconcerts all our habitual modes of thought—but we shall at length reach a positive conclusion from which all the old paradoxes have fallen away, a conclusion which *must* be true, if our physiological basis is sound. For, although so many of the older problems of metaphysics are insoluble, the relation of mind and matter is not insoluble. I venture to think that its solution is contained within the later advances of physiology.

Chapters V and VI describe the main principles of materialism, which appear to emerge from the preceding review of scientific conclusions. Those conclusions seem to me to lead to a most uncompromising and complete materialism; but they also lead to a no less uncompromising idealism. In short, the old antithesis between materialism and idealism vanishes completely. They are not two rival doctrines; but they are one and the same doctrine, looked at from different aspects and stated in different words. So long as mankind are a prey to the dualistic superstition—the belief that mind and matter are two fundamentally different things—so long will the two rival philosophic doctrines remain reared up in antagonism against each other. But once the position of monism is accepted, the antagonism falls away. There are no longer two fundamentally different things; and no longer will there be two opposed philosophic theories as to their nature.

I have approached the subject from the point of view ot materialism, not because I regard it as any truer than idealism, but because it is a far more fertile aspect from which to view the facts. Idealism enunciates a single truth, which goes no further and leaves nothing more to be said. Materialism enunciates the same truth in different language; but that is only the beginning: it leads much further; in fact it leads everywhere that the human intellect can reach; it lies at the basis of science, of history, of human activities.

The theory of Chapter VI appears to come near to the views which Mr. Bertrand Russell has reached by the methods of pure logic alone. At all events, I have often been astonished to find in his works conclusions so harmonious with those deducible from physiological principles, and yet attained by sheer force of reasoning from altogether different data. But in other respects the conclusions of this book are very different from those of Mr. Russell.

The theory is in a much closer accordance with the Radical Empiricism of William James; but James again reached it by metaphysical means. Moreover, he took the view that it was allied to indeterminism, theism, etc., and opposed to Agnosticism and scientific naturalism or positivism—a view very difficult to understand, since my one reason for believing in it is that it is the only theory compatible with physiological mechanism. Once the dualistic theory of epiphenomenalism is abandoned—as it is now abandoned on all sides—there remains no alternative whatever but to accept Radical Monism, unless, indeed, we are prepared to admit the hypothesis of Vitalism, which is entirely opposed to physiological principles. James did, in fact, much against his will, recognize the materialistic implications of his doctrine. He remarks: "I greatly grieve that to many it will sound materialistic." It sounds materialistic because it is plain materialism, though why that should be a cause of grief I do not understand. The essence of the theory is that there are not two different things, "mind" and "matter," but one thing, "pure experience," which takes the form of psychical or physical according to its associations. To James, it was a theory of epistemology; to me, it is a theory of physiological psychology. "Philosophers," he writes, "have constructed the entity known to them as consciousness. That entity is fictitious . . . *thoughts in the concrete are made of the same stuff as things are.*" No materialist could wish for more; and yet is it not just what idealists have always said from the time of Berkeley onwards? The old antithesis has vanished.

This book is published at a time when there is much talk of "reconstruction." The need for reconstruction is plain enough in industry; but it is still more urgent in the realm of ideas. Let us reconstruct our ideas in accordance with the truths of external nature. Once we get into true habits of thought, the rest will flow from it without any special contrivance. Nothing can be more palpably false than the system of ideas now reigning throughout civilization. The Church for two thousand years has dominated opinion: and see the result. If humanity ever learnt by experience, they would assuredly hasten to the most extreme form of materialism they could find. For things are not what they seem to be on the surface. Christianity does not lead to an age of universal brotherly love, as we might expect from its doctrines; nor does materialism lead to any of the alarming consequences which its numerous enemies endeavour to anticipate.

There are many who think they can get on very well without any kind of philosophy. But philosophy is no more than a name for our general outlook upon the world. Every one has a philosophy of some sort, however little they may be conscious of it. Such ideas as men possess are governed and directed by their general mode of thought, and the man who truly has no philosophy is a man whose head is empty of ideas. All that is urged in the present work is that we should fashion our ideas in conformity with what we know of external Nature, and not according to the precepts of any artificial system. Let us look boldly at things as they are; let us cease fabricating our beliefs in accordance with what we *desire* to believe, and let us believe only what we perceive to be true. No man can have a true philosophy, unless he has discarded much that he would have preferred to keep and accepted much that he would have preferred to reject. There is often bitterness in truth. He who does not know it is as yet undisciplined, and may be sure that his philosophy is false. For the bitterness is in Nature itself; truth is quite independent of our personal predilections. So long as we admit error into our philosophy, our actions will accordingly be wrong. The bitterness *has* to be; better that it should be experienced in the realm of thought than in that of action. For when once we have acquired true habits of thought the fight is over; true modes of conduct and activity flow inevitably from them.

CHAPTER I

THE UNIVERSE AS A WHOLE

As we look at the skies on a starry night, we cannot help asking ourselves questions about the nature of the Stellar Universe, of which we form so insignificant a part. What is the distance of these stars? What is the condition of them? Do any of them support life such as we know it? And, furthermore, do they continue to be scattered at intervals to the most remote depths of space; or is the Stellar Universe a mere island situated in the midst of infinite void?

Modern researches in stellar Astronomy have begun to suggest answers to some of these questions, which not many years ago were shrouded in the blackest veil of mystery. It is still true that precise answers are usually not available; and such answers as can be given are frequently dependent on speculations which leave considerable latitude for error. Science abhors speculation: it confines itself only to those facts which can be ascertained by the (often) laborious processes of observation and experiment, and to a certain number of cautious deductions from them—deductions which are unsafe for any but the highly-disciplined scientific mind to attempt. Nevertheless, it is not only legitimate, but imperative, that an attempt should be made to appreciate the larger significance of modern discoveries—to ascertain to what theory of the Universe these discoveries are tending. Naturally, our conclusions must contain a large amount of speculation. They do not profess to state the actual structure of the Universe; they profess only to describe that theory of the Universe which modern research has rendered more probable than any other theory. Within large limits, these conclusions are certainly correct; but in many of their details modification will be required as our knowledge continues to advance.

On some questions, indeed, it seems almost inevitable that we must for ever remain in ignorance. How, for instance, can it ever be known whether there exist stars right away to the uttermost limits of space? We cannot even ask the question intelligently; for we cannot think of any limits to space. We cannot imagine to ourselves any limit, without at the same time being always able to think of regions a mile or a hundred miles beyond that limit, even though measured through absolute void. And where rational questions cannot be framed, there can be no hope that rational answers will ever be given. We quickly reach the point where mere human knowledge—and the possibility of human knowledge—breaks down utterly in contact with the infinite and the unknowable. Our science is like a small candle set in the midst of infinite and pitchy darkness. It helps not at all in seeing things that are a million miles away; and even if we succeed in multiplying its light a million-fold, we shall still be no wiser as to space a trillion miles away, and we shall have approached no nearer the solution of infinite distance or the boundaries of space.

Nevertheless, recent study goes to show that all those stars which we can see at night, and all those others, vastly more numerous, which are disclosed by powerful telescopes, do constitute a sort of single island-universe, in the midst of infinite space. If the stars were scattered continuously throughout space, we should expect to find that, as each new power of the telescope brought into view a fainter class of star, this fainter class would be more numerous in a certain proportion than the brighter stars previously known. They are, in fact, found to be more numerous, but not in the expected proportion. Observation suggests that, at a certain remote distance, the stars become rarer, until at length a region is attained where there exist no stars at all.

We must, then, consider our Universe as an isolated system of stars and nebulæ; and the question arises as to what shape this system would appear to be if we were able to survey it from an external position. It is not found to be a sphere, as might have been expected; it is an oblate spheroid, like the Earth itself, only with a more pronounced oblateness. That is to say, our Stellar Universe appears to be flattened, say, above and below: the stars tend to be situated in a single flat plane, but they are scattered sufficiently on each side of this plane to approach a spherical distribution.

If, once again, we look out on a starlight night, we see a great belt of luminous material stretching right across the sky; this belt is the Milky Way. It forms a complete ring external to the whole Stellar System, and more remote than the stars which form that system. We must conceive the Universe, therefore, as a flattened-out sphere surrounded by a ring, the ring being approximately in the same plane as that in which the Stellar System is flattened. The ring, constituting the Milky Way, must not be considered as quite separate from the inner system of stars: the connection between them will be referred to later.

It is now necessary to obtain some idea of the magnitude of our Stellar Universe. The distances with which we have to deal are too vast to be conveniently reckoned in miles. We require some unit of measurement far larger than the mile; and the unit most convenient for our present purpose will be the "light-year"—that is to say, the distance travelled by light in the course of one year. This unit is equal to 5,875,226,810,000 miles. Light travels at the rate of rather more than 186,000 miles per second. The distance of the Sun may be estimated from the fact that its light takes about eight minutes to reach the Earth. But distances within the Solar System fade into nothing by comparison with the distances of the stars. The nearest of the fixed stars is *a* Centauri, a bright star visible only in the Southern Hemisphere. The distance of this star is such that its light takes four years and three months to reach us.

When we pass from the nearer parts of the Universe to the more remote, the distances with which we have to deal transcend all power of the imagination. It has already been stated that the Milky Way forms an outer ring about our star system. Various estimates have been made as to its distance; but the lowest estimate for the nearest parts of the ring place it at a distance of nearly 4000 light-years; that is to say, the light travelling from it to the Earth at the continuous velocity of more than 186,000 miles per second will take nearly 4000 years to arrive. Other estimates are still larger; one, for instance, reckoning the time at over 16,000 years from the nearest parts of the Milky Way.

Now it follows from these figures that when we look at the Milky Way, we see it, not as it is now, but as it was several thousand years ago. Conversely, supposing that there exist in the Milky Way other suns and planets inhabited by people like our own, they, looking out upon the Earth, would see it, not as we know it, but as it was perhaps when palæolithic man was chipping his rude flint implements, or sheltering in caves from the rigours of the Great Ice Age.

It must not be supposed that there is anything fanciful or improbable in this hypothesis. Mankind, as a rule, are so much bound down by the narrow conceptions and interests of their own lives, that they constantly fail to realize anything that transcends the boundaries of their personal experience. The hypothesis that life exists in other parts of the Stellar Universe is neither fanciful nor improbable. On the contrary, it is far more in accordance with the available data than the opposite hypothesis. The public have long been interested in discussions as to whether there is life in the planet Mars, the suggestion being based upon the presence of supposed canals on the surface of Mars, which have some appearance of human workmanship and design. It is hard to say in this particular case that these canals afford evidence of any real value towards the presence of life. All forms of life with which we are acquainted are conditioned by a certain kind of physical environment: life can only exist, for instance, between certain limits of temperature, and only where there exist sufficient quantities of various elements (such as carbon, oxygen, nitrogen, hydrogen) to constitute organic matter. If we take any one heavenly body, as, for instance, Mars, the chances are certainly against *all* the physical conditions of life being present. But if we estimate the chances of these conditions being realized on *some* of the bodies of the Stellar Universe, the probability becomes so high as to amount to a practical certainty. Our telescopes disclose to us very many millions of stars in the sky, and every increase of power brings into view further millions. And these are only the luminous bodies. There can be no doubt whatever that the number of dark bodies, of which we must remain ignorant, is also exceedingly great, very possibly much greater than that of the luminous bodies. Is it to be supposed that among these countless millions, one only—the one we know—supports life? Moreover, every star and every planet passes through the same stages of evolution. Beginning as a gaseous body of vast extent, heat, and luminosity, it gradually contracts, solidifies, loses its luminosity and heat, until it becomes dark and dead, without motion of any sort upon it, and fallen to the temperature of space—the absolute zero of cold. The Earth has reached a certain stage of that evolution. All the older stars and their planets have passed through that stage; all the younger ones are approaching it. Scattered through the Universe there must be innumerable bodies which are approximately at the same stage as the Earth. Moreover, the spectroscope has shown that the stars are composed of the same kinds of matter as our Earth. In many bodies of the Universe, the conditions, therefore, cannot be very different from those in which we ourselves are placed. Are we to say that on our Earth alone exists any form of life? We know that similar causes of necessity give rise to similar effects; and if we find life on the one body of which we have experience, the law of probability requires us to believe that on very large numbers of other bodies, outside the range of our observation, life must also exist.

But not necessarily just that kind of life which we know. Living organisms on the Earth are primarily classified into the two great divisions of animal and plant. But we have no right to infer that there can be no other kind of life than what can be brought under one or other of these two divisions. Where the physical conditions are extremely similar to our own, we may, indeed, expect that the forms of life will also be not widely different. But where there are considerable dissimilarities, we should not be surprised to find species and evolutionary chains which could not be brought within the limits of terrestrial classification. The dominant forms of life elsewhere may be as different from animal or plant as these two are different from one another.

Biologists are generally agreed that life is a product of physical and chemical conditions. If a particular set of conditions has produced life upon the Earth, then the repetition of that set of conditions in some other part of space will, with the same inevitableness, produce life there. If the set of conditions is *identical* with our own, then also the forms of life will be identical. It is, however, exceedingly improbable that absolute identity can anywhere be realized. The mere fact that there cannot be identity of position—for the other bodies are situated in other parts of the Universe—introduces at once a difference. The forces exerted upon the body by neighbouring bodies, and by the centres of gravity of the Universe, will be somewhat different; and small though the difference may be, it will assuredly suffice to affect profoundly the character of life which becomes established; for we know how delicately species are adjusted to their environment, and how any change of the environment causes (indirectly rather than directly) a corresponding change in the species filling that environment. Probably organic evolution on the Earth has been controlled by an infinite number of external factors, severally quite minute. A difference in any one of these factors would have affected profoundly the development of species. Since we are bound to suppose that in other parts of the Universe, even in those parts most closely resembling our own, the factors which control organic evolution will differ in various respects from the factors to which we on the Earth are and have been exposed, we are equally bound to infer that the species in those other parts of the Universe will be correspondingly different.

When, therefore, we inquire what are the probabilities as to any one species, such as the human species, existing elsewhere, the answer becomes much more speculative and difficult. It all depends how numerous and how specialized are the factors which have led to the evolution of that species. In proportion as the number and specialization of those factors are high, the probability of their reproduction elsewhere will be remote. It seems probable that the human species has arisen in response to a vast collocation of highly specialized factors, any alteration in which would have led to corresponding alterations in the structure, and therefore in the functions, of the species. For the human organism is almost infinitely packed with *detail.* There are various different kinds of tissue, and a great congeries of diverse organs, each dependent on all the rest. The heterogeneity and complexity are in profound contrast to the homogeneity and simplicity of the most elementary forms of life. It seems probable, therefore, that the historical factors which have brought about human evolution are likewise incredibly heterogeneous and complex, and are correspondingly unlikely to have occurred in the same collocation in other parts of the Universe. We can have no difficulty in perceiving that in many parts of the Universe there must have arisen the little specks of undifferentiated protoplasm from which life starts. Nor can we have any difficulty in supposing that these specks will start off on various lines of evolution, as they have done on the Earth. But those lines of evolution will be controlled by the local conditions; and as we have to assume some variety in local conditions, we have also to assume variety in the species which are ultimately evolved. In comparing stellar species with our own, we should expect to find resemblance on broad lines only, combined with multitudinous differences of detail.

The next question naturally arising concerns the probability of the development of intellect in other parts of the Stellar Universe. Is there likely to exist anywhere knowledge, as we understand the word, or any comprehension of physical truths, or any power of consciously altering the environment, such as we possess to some trivial extent? The answer to this question again depends on the further question as to how narrowly specialized are the factors which favour the evolution of intellect; and this question is one which biologists cannot answer. We may well believe, indeed, that the factors in operation are far more numerous and intricate than those which from time to time have been suggested—such as the opposability of the thumb, or the power of speech. But we may also note that intellect of a rudimentary kind is characteristic of many different lines of animal evolution on the Earth. An insect or crustacean or fish may not have an intellect comparable to our own; but they certainly have the rudiments of it. The raw material of intellect is distributed widely among the species of the Earth, and we shall, therefore, perhaps be justified in assuming that the physical factors which produce this raw material are not very precise or circumscribed. It would not be surprising to find that in remote globes the conditions are sufficiently similar to produce something analogous to what we understand as intellect; and if the raw material of intellect is scattered at large throughout the Universe, we shall not be stretching our imagination too much if we suspect that here and there it may have blossomed forth as it has done in the one globe of which we have experience. Very probably, indeed, such intellect may be widely different from ours. It may be manifested in organisms altogether different from ourselves. It need not necessarily be based, like ours, on the senses of sight, touch, and hearing; but upon an altogether different set of senses, of which we have no cognizance or conception. And yet it may be not less powerful than ours: it may, indeed, be far more powerful. In some of the myriad stars which shine upon us by night, there may dwell beings who even at this moment are following the doings of humanity on earth, who may even know that at this moment we are writing about them, and that you are reading about them.

We are accustomed to regard ourselves as lords and masters of creation. We forget that we live upon a minor planet revolving around a minor star. We forget the miserable smallness of the Earth, which passes through all its transformations from luminous gas to dead, dark, solid in a period that would scarcely be more than a day in the life of one of the larger stars. If, in one of those stars, evolution gets to work on organic matter, the time it will have available vastly transcends anything we know upon the Earth. What evolution can do in a day upon the Earth, may it not do far more completely when it has a million years to work in? On some of those distant stars there may well be intellect comparable to our own; there may well be intellect which transcends our own as greatly as ours transcends that of a butterfly.

With this possibility in mind, let us turn our telescopes once more upon the heavens to see whether we can find any traces of artificial interference with the regular uniformity of Nature. On the surface of one of the nearest planets there are markings which many have held to be the work of conscious beings; but the evidence on which that supposition is based is too slight to throw any light upon the question, or to strengthen the probabilities one way or the other. In no other part of the Universe can we detect the smallest deviation from the blind process of natural law. The various stars and planets swing on their courses under the absolute control of the Laws of Motion and Gravitation; in the myriads of stars which shine feebly on the Earth, not one furnishes the smallest indication of any kind of living process. We seem to be alone in the midst of infinite, silent, and lifeless space.

This observation, however, carries us but a little way. In the first place, no artificial construction could be detected by our existing methods, unless it was of such magnitude as to obliterate the light or alter the course of a powerful sun in a very striking and conspicuous degree. The highest flight of human intellect has enabled us to do no more than effect certain insignificant changes on very limited portions of the Earth's surface. Our achievements are like the scratchings of a field-mouse on the side of a mountain. Such scratchings could not be seen except by the closest observation, and for an observer at a distance they would for ever be hopelessly outside the range of discovery. To give any chance of discovery, the entire mountain must be moved—and must be moved in a conspicuous manner, plainly not in accordance with natural processes. The fact, therefore, that we see no signs of interstellar life must be taken in conjunction with the fact that we *could* see no such signs, unless the agency which wrought them were possessed of a power inconceivably greater than our own. We find no signs of interstellar intellect on a large scale; but that fact has no real bearing upon the problem of life. We have nothing but analogy to argue from, and the utmost that analogy can lead us to is a form of life which may modify the surfaces of stellar bodies, as we in our small way modify the Earth's surface. Any such modifications—

any modifications even of immeasurably greater extent—would yet remain far beyond the range of our most powerful scientific instruments.

Bereft of the method of observation, we fall back, therefore, upon that of analogy, the only weapon of logic with which the problem can be touched. And recognizing to the full the shortcomings of that weapon, we are yet bound to infer from it a very high probability that life is scattered in various parts of the Stellar Universe; and a considerable probability of intellectual life, very likely far more powerful than our own.

Let us suppose, then, that such life exists in parts of our Stellar System distant a couple of thousand light-years from ourselves. Let us suppose that intellectual organisms living there are in so far similar to ourselves as to be susceptible to the æthereal undulations of light. What would such observers see if they are now directing their telescopes upon the Earth? They would see it, not as it is now, but as it was when Christ was alive. If their instruments are sufficiently powerful, they may at this moment be watching the incidents of the Crucifixion and the burial of Christ. Or they may observe Cæsar conducting the Gallic Wars; and in England, perhaps the Druids worshipping in the temple of Stonehenge, over a thousand years before the Norman Conquest. To them our present doings upon the Earth will remain unknown for another two thousand years—veiled in the impenetrable darkness of the future. Their present is our past; so, too, our present is their past. The star under whose shelter they live may, for all we know, have been swept away by a cataclysm in the age of Augustus. Yet it still continues to twinkle peaceably upon us at night; its past alone is all that exists for us, and we can no more say what has happened to it later than we can prophesy what is going to happen to ourselves. Not infrequently, indeed, we do witness in the heavens a sudden new star which shines with great brightness for a time and then fades away again from view. In such cases we know that we are witnessing some gigantic collision or cataclysm which occurred in the depths of space long ages ago. We must modify our conception of the present. As we include within our gaze an ever-widening sphere of space, we are at the same time transferred ever more remotely into the ages of the past. Our journeys into the distant regions of space are at the same time journeys backwards along the stream of time.

Some persons have even suggested a still more daring speculation. It has already been stated that light travels at the rate of 186,000 miles a second. It follows that, at a point distant from the Earth 186,000 miles, we should see the Earth as it was a second before. Plunging still further into space, we should reach points from which the Earth would appear as it had been an hour previously, a day previously, a year previously, and so on indefinitely. Now it is an axiom of science that no motion can ever be lost; and the æthereal undulations of light, if not absorbed, must continue travelling for ever into the depths of space. For a knowledge of the condition of the Earth at any special past period, it is only necessary, therefore, to take up our position at a distance from the Earth where the light emitted during that period is just arriving. The whole history of the Earth is written in expanding spheres of light stretching away to infinite distance. *Every* event that has occurred upon the Earth is now working its effect upon the æther at *some* remote region of space; nor is it possible to go back so far in our history that we cannot indicate a part of space where that history is now being recorded in present time, and would leave its impress upon any photographic plate of sufficient delicacy to receive it. It has been suggested, then, that the history of our Earth may be reflected back to us, possibly by intelligent beings in another part of space, possibly by a device of our own to catch it, so to speak, and fetch it back. If this wild speculation could ever be realized, and if our instruments could be refined to an infinite degree, we might yet be able to see for ourselves and to photograph for ourselves the actual event of the Crucifixion of Christ. There is no difficulty whatever in naming the portion of space in which that Crucifixion is now occurring as part of the *present*, to any beings who may live there.

Passing now from the problem of life, let us revert to the known structure of our Stellar Universe. As already explained, the Universe assumes the form of a sphere, somewhat compressed on two opposite sides. It is described as being of the shape of a bun, and is surrounded by the ring of the Milky Way in approximately the same plane. We have attempted to give some idea of the distances of the various parts of the system. We have now to take note of a further fact, namely, that the stars are not "fixed," but are all in motion, though their immense distance renders their movement very difficult to detect. Their motions may be in any direction, though certain directions are more favoured than others. Velocities also vary within wide limits. The star which moves most rapidly of any yet detected is known as Lalande 1966, which is travelling through space at the approximate speed of 200 miles a second. Another high-velocity star is C.Z. $5^{h.}$ 243, which is moving at about 150 miles a second. It may, perhaps, be considered fortunate that it is moving away from ourselves; and, in fact, part of its apparent motion may be set down as due to our own motion in the opposite direction. For it is to be noticed that there does not anywhere exist in Nature an *absolute* standard of rest or motion. We can never know more than the *relative* motions of bodies. We can ascertain that two bodies are approaching or receding from one another, and we can ascertain the amount of this relative motion; but we cannot say whether one or other or both are moving, unless there is some outside standard of comparison; and when we deal with the Universe there is no such outside standard. All we see is a group or system of stars changing their positions relatively to one another.

The average velocities of stars are very much lower than those above named. The Solar System itself moves at about thirteen miles a second. If the reader has followed this chapter at all carefully, he may reflect that he is just now more than 5000 miles away from that part of space in which he began it, and, indeed, that he has travelled forty or fifty miles since he began the present sentence. It is curious that the planetary nebulæ are found in general to move more rapidly than stars. These nebulæ consist of clouds of luminous or dark material occupying inconceivably vast tracts of space. It is useless to make an attempt to give an idea of the magnitude of such nebulæ: the area covered by the whole Solar System is negligible in comparison. These nebulæ, notwithstanding their tenuity and their immense magnitude, swing along through space at an average rate of more than fifteen miles a second, whereas many of the brighter stars do not attain a quarter of that speed. The direction of motion of stars is not altogether haphazard. In various regions of the sky are to be seen clusters of stars which appear to be moving together with the same velocity and in the same direction, and are supposed to have had a common origin. Their velocities, indeed, may be estimated to differ by not more than a few yards a second; for any greater difference would have led long ago to the dispersion of the group. In illustration of such clusters may be mentioned the Pleiades and also the Taurus cluster, both visible on winter evenings high above the southern horizon. A better known but more widely scattered cluster is that which includes most of the principal stars of the Great Bear; and with them is supposed to be associated even so distant a star as Sirius.

In addition to these localized star-clusters, it is found that the movements of the stars as a whole tend in two main directions. That is to say, although there are stars moving in every direction, and others which scarcely appear to be moving at all, yet there is evidence of some influence at work which tends to divide the Stellar System into two star-streams moving in opposite directions through one another and independently of one another. The explanation of this fact will be considered later.

We now pass on to consider the methods by which the motions and distances of stars are discovered. The distance is determined, as a rule, by the same method that distances of inaccessible objects on the Earth are determined. A base-line is carefully measured, and then the exact angular direction of the distant object is measured from the two ends of the base-line. The further the object and the shorter the base-line, the smaller is the difference of direction of the object as viewed from the two ends of the base-line. Where, as in astronomical investigations, the object is excessively remote, the angular difference of direction in which it appears from the two ends of the base-line is excessively small. It is necessary, therefore, to make our base-line as long as possible. This may sometimes be done by taking two points on exactly opposite parts of the Earth's surface. The distance through the centre of the Earth of two such points is about 8000 miles; and this may be used as a base-line, from the ends of which the parallax, or difference of direction in the apparent position of the object, may be attained. In practice, however, such a base-line is far too short: 8000 miles dwindles to a point in the computation of astronomical distances; and no results can be obtained from it.

The base-line commonly used, therefore, is the diameter of the Earth's orbit. The apparent direction of the distant star is accurately measured; in six months' time it is then accurately measured once again. The Earth has by now swung round to the opposite side of the Sun, and the object can thus be viewed from two comparatively widely separated points in space. But even this base-line is too short for measuring the distance of any but the nearest stars, and calls for extreme delicacy and refinement of the measuring instruments. The only available method of obtaining a still longer base-line is to wait a few years between the two observations. In the course of that time, the Earth and the whole Solar System will have moved a great distance through space, and this distance may be employed as a base-line; though here further inaccuracies are introduced owing to ignorance of the exact length of this base-line.

The motions of stars are in part determined on the same principle. The motion in question is of two kinds: firstly, that across the line of sight, called proper motion; secondly, that directly towards or away from the observer, called radial motion. The motion of every star is made up of these two component motions.

The calculation of proper motion is simple in principle, though singularly difficult in practice. Proper motion is seen, of course, as a change of the star's position in the sky. Owing to the great distances, the visible changes of position are very minute. Moreover, accurate observations were only taken in comparatively recent times. If we had records of the exact positions of stars two or three thousand years ago, and could compare them with their positions now, we should have in many cases a good idea of their proper motion; but in fact reliable observations do not extend back for more than about 150 years.

The radial motion presents a problem that at first sight appears far more difficult, but which in fact is much easier. Not many decades ago, the problem of measuring radial motion appeared to be not only insoluble, but necessarily and for ever beyond the reach of human intellect. For a star is nothing more than a point of light, and its motion towards or away from the observer does not alter its appearance in the smallest degree. Unlike a planet, it has no visible disc. If we turn any small telescope on to the planet Jupiter, we recognize at once a visible disc. It is more than a mere point emitting light. But when we come to deal with a star, it is, and always remains, a point: not the most powerful telescope in the world can make it more than a mere point of light. How then can its motion in the line of sight ever be detected?

This question was answered by the spectroscope, an instrument by which we can learn, not only the radial motion of a star, but also the chemical substances of which it is composed. When a star is moving towards us, the waves of light which it emits are compressed, and therefore follow upon one another with unusual rapidity. When, on the other hand, it is receding, the æthereal undulations are drawn out and follow one another more slowly. The spectroscope can estimate the number of light waves arriving in a given interval, and hence can be deduced the motion of the luminous body in the line of sight. By compounding this motion with the observed proper motion of the star, the actual amount and direction of motion are obtained.

A few words must be said concerning the origin and development of the Stellar System. The common hypothesis is that the stars have developed from nebulæ, which may be described as masses of attenuated cloud of incredible dimensions drifting through space. Such a nebula is to be seen in the well-known constellation of Orion. From parts of this nebula it is believed that new stars are slowly continuing to be formed, and the nebula itself is travelling through space with the same velocity as neighbouring stars which presumably have been formed from it. It is still a subject of controversy as to what is actually the constitution of a nebula; they are now often looked upon as vast collections of meteoritic fragments constantly colliding with one another. But stars may still be regarded as drops condensed from a nebula-cloud. During the first stage of condensation they increase in temperature and brightness; then gradually the radiation into space of heat and light begins to take effect, and the star slowly becomes cold and dark, while contracting to form a tightly-compressed solid globe. While this process is occurring, the star often splits up, and so may come to form a planetary system like our own. Nearly half the entire number of stars are "binaries." That is to say, the original star has split into two, of approximately equal size. These two are closely bound together by the mysterious and invisible bond of gravitation. They revolve like a couple of dancers round their common centre of gravity. In course of time, as age overtakes them and they become cold and dark, their distance increases. Various forces, notably that of tides, retard their motion; till at length the two dead spheres swing slowly round one another, separated by great distances.

On their first formation, stars as a rule appear to have slow motions; but as they decrease in brightness and in heat they gather speed, and the linear motion of a dead star is probably much higher than that of a living one. The bright stars of Orion are comparatively young; they move also at slow velocities, which will in the course of ages probably become trebled. Moreover, the origin of stars appears to take place chiefly in the plane of the Milky Way. As their age increases, stars tend to wander from this plane, and are scattered more evenly through the heavens.

The causes of stellar motion are very little understood. The distances between individual stars are so great that mutual gravitation is very slight. The star nearest to the Sun is *α* Centauri; yet, notwithstanding its proximity, the attraction of the Sun acting upon it for a year does not suffice to impress upon it a velocity of half an inch per hour. The stars thus seem to move independently of one another, though they are subordinate to the general attraction of the whole system. Under the influence of this general attraction, they appear to swing backwards and forwards like a pendulum from one border to the other of the sidereal Universe. On the outskirts of the Universe, the motion of the star would be slow; but it would gather force as it approached the centre. If the stars are really oscillating to and fro in the Stellar System, it is conjectured that their period of oscillation would be of the order of 300,000,000 years, and the general age of our Stellar Universe would be reckoned in thousands of millions of years.

We are still no nearer an answer to the question with which we opened this chapter: Are the stars scattered about to the end of space, or are they clustered into a single system poised in the midst of infinite void? We have, indeed, seen reason to believe that the visible Universe is bound together into a single system. It is not altogether easy to say whether certain sidereal objects do or do not belong to the system. Such is the case, for instance, with the Lesser Magellanic Cloud, whose distance is so incredibly great that its light takes over 30,000 years to reach the Earth. There are yet other objects, immeasurably remote, which appear to be altogether outside our Stellar System. These objects in particular are the spiral nebulæ, some of the most beautiful bodies in the heavens. They consist of a dense core or nucleus, with nebulous matter coiled spirally around them. The suggestion has been made that these spiral nebulæ are nothing else than other stellar universes similar to that which we have hitherto described. If our Stellar System is, in reality, a spiral nebula, and if our Sun is situated near the nucleus, then it is reckoned that the nebulous arms coiled spirally around the system would assume very much the appearance actually observed in the Milky Way. Moreover, the two principal star-streams, before mentioned, would represent the streaming of matter to or from the nucleus into the nebulous arms, of which two have always been observed.

We reach the conclusion, therefore, that although all the visible stars are united to form a single universe, there very probably exist other universes divided from our own by infinite tracts of void. Our imagination will not allow us to set any limit either to the numbers or the distances of such other universes, which may well be spread in endless succession throughout the infinity of space. Nor have we the slightest grounds for denying the probability of life scattered equally far beyond the confines of our own Universe. The more numerous the bodies which occupy space, the more unlikely does it become that we alone display the manifestations of life. Who shall say that we are not even now under the surveillance of intellectual beings in another globe and another universe? All we know is that, if they depend upon light for their information, they certainly know nothing of us as we are now. They see the Earth, perhaps, long before the evolution of man: in their telescopes it is still peopled with Dinosaurs and strange reptiles which for untold ages have been extinct. It is possible, however, that they are not dependent upon light; but have some sense that it is based, for instance, on gravitation. Presumably, gravitation acts instantaneously through space—it is not transmitted like light—hence, changes in the distribution of matter may have instantaneous effects to the uttermost limits of the conception of space.

The unity of our own Stellar System seems to be indicated by the comparative homogeneity of the masses and motions observed. The masses of the stars do not vary between very wide limits; their motions too are of the same kind of order. In a universe entirely out of touch or any relation with our own, we might expect to find at least an infinite variety of motion. Rest and motion are only relative; and if another universe has never had the smallest connection with our own, its velocity through space, relative to ourselves, may be of an order utterly beyond the range of our imagination. It is, indeed, more likely to be so than not. But supposing the velocity of another universe were so far commensurable with our own as to resemble that of light by comparison with our own; then observers situated there would, if their world was approaching ours, see[1] the events of centuries crowded into minutes, just as the cinematograph displays a plant growing to maturity in a few seconds. On the other hand,

[1] Not, of course, by direct vision, but through an instrument adapted for the detection and transformation of the æthereal waves.

if the observer was receding with a velocity approaching that of light, events which occupied minutes on the Earth would be protracted to centuries. As his velocity increased, events on the Earth would appear to stand still: all animation would appear to have been suddenly arrested and frozen where it was. With a still greater velocity, a yet more curious result would be witnessed. Events would seem to move backwards, and the history of the Earth would be gradually retraced from the later to the most ancient periods. Moreover, the Earth would not be seen by looking towards it, but by looking in exactly the opposite direction; for the observer would be catching up the rays of light emitted from the Earth, and he would, therefore, only come in direct contact with them on the side of his globe most remote from the Earth.

Such speculations are to some extent invalidated by the so-called Principle of Relativity. According to this doctrine, itself of highly speculative character, all objects become flattened in the direction of their motion through space: motion actually changes the shape of the moving body. As the velocity of motion approaches that of light, the flattening tends to become infinite, until at the actual speed of light the body would cease to have any thickness at all in the direction of its motion. It would then exist in two dimensions only, instead of in three. From this it is inferred that no material body can possibly move so rapidly as light. The Principle of Relativity is far from being regarded as an established fact; but it is one of the most curious hypotheses ever framed by man.

However speculative our theories may be as to the general form of the Stellar Universe, they serve at least to bring home one point of fundamental philosophic importance—the triviality and unimportance of Man in the system of Nature. The early speculations of the human race were founded on the assumption that Man was the centre of all things, the purpose for which all things existed. Every individual even now passes through this age of speculation, equally characteristic of the childhood of the individual as of the race. But as we advance in knowledge and mental power, we tend more and more to see mankind from a wider point of view—no longer the centre of the Universe, but an insignificant item, of no intrinsic importance whatever, except to themselves. They live merely upon the surface of a planet revolving round the Sun. There are seven other such planets of considerable size revolving round the same Sun, and there are nearly a thousand known minor planets, varying in size—the largest having a diameter of about 485 miles, the smallest of fifteen or twenty miles—mere rocks flying through space, the smallest objects that our telescopes can see. The major planets, again, have their satellites; and the whole solar system thus made up is a mere unit among myriads of others in the Stellar Universe. That Universe itself may be only another single unit, among a multitude of other universes; and if at this point we cease to speculate, it is not because there is no further scope for speculation, but because we have already far outstripped the last shred of solid evidence that our instruments can provide for us. Complete and absolute darkness reigns beyond. If we learn nothing else for certain, we learn at least this: that the farther we travel, the more obscure and insignificant does Man appear. And three points also emerge, which we shall have occasion to impress later on. Firstly, the uniformity of natural "law" remains as absolute in these regions of infinite greatness as in our own world of human dimensions. Secondly, no sign of purpose can be detected in any part of the vast Universe disclosed by our most powerful telescopes. Thirdly, this great new sphere of experience affords not the smallest trace of evidence for the existence of any spiritual entity. We find nothing but unimaginable tracts of space and time, in which move bodies by fixed laws towards ends which are wholly fortuitous, and have not the smallest relation to the advantage or requirements of Man.

CHAPTER II

MATTER AND ENERGY

When we look round us to find out what kind of objects or phenomena the Universe consists of, we shall at first sight notice three different groups in which all the facts of our experience may be comprised. In the first place, there is what we know as matter, existing in three different forms, of solid, liquid, or gas. In the second place, there are facts of a different character: heat, light, sound, electricity, motion, which appear quite different from what we know as matter, but have something in common with each other which causes us to place them all in one main group of external phenomena. In the third place, there is yet another order of facts, which can be loosely designated under the appellation of life and consciousness. At first glance, these vital and mental phenomena appear to have nothing in common with either of the two other groups. Their processes take place *within* us and are subjective, whereas the processes of the other two groups are *outside* us, and therefore objective. In these three fundamental categories all the facts of human experience are comprised.

This analysis into three categories is, however, merely provisional. It arises from our first casual glance to see what is the raw material out of which the Universe is exclusively built up. A closer examination reveals the fact that the differences between the groups are more apparent than real, and that when we come to inquire more closely into the actual constitution of each, the differences sink away, and lead us to believe that the Universe is built up, not out of three different kinds of raw material, but from one kind only, which manifests itself to us from three separate points of view. The third group, that of life and consciousness, is dealt with in the following chapter; the present chapter is devoted to a closer analysis of the first two groups.

As regards matter, the fundamental property by which it is distinguished is that of *inertia*. That is to say, if any portion of matter is at rest, it cannot start into motion without the action upon it of some external force; if it is already in motion, it equally cannot alter its velocity or direction of motion without the action of an external force. Resistance to change in its state of rest or of motion is the fundamental property of matter.

As regards the second group, heat, light, electricity, etc., the name adopted for this class of phenomenon as a whole is *energy*. Just as matter has one fundamental characteristic, that of inertia, so energy has a single distinguishing mark, namely, the capacity for doing "work." By this is meant that it can give rise to a force which is capable of overcoming the inertia of matter, and thus causing motion in a portion of matter previously at rest.

The first great Law of Physics is equally applicable to both matter and energy. It states that matter and energy are alike indestructible and uncreatable, and that such changes as we observe in them are changes only of form, during which in either case the absolute quantity is totally unaffected. We burn a lump of coal, and matter *seems* to have been destroyed; but if we collect all the ashes that remain and all the particles, solid or gaseous, that have been emitted as smoke during the combustion—if we collect all these products and weigh them together, we find their total weight to be identical with that of the lump before it was burnt. So also in the sphere of energy. If we drop a stone from a height to the ground, its energy of motion appears to be suddenly destroyed. But measurement has shown that at the precise moment when the motion of the stone is arrested, there come into existence new forms of energy, which, on being added together, sum up to the exact equivalent of the vanished motion. These new forms of energy are of various kinds. Much of it will appear in the form of heat at the point where the stone strikes the ground. Some will appear in the form of aerial vibrations, which we know as sound. There may also be an emission of light; there may be electrical or magnetic effects; and there will probably be a sudden appearance of small quantities of energy in various other different forms. When all these new forms of energy are reduced to a common basis and added together, their sum is found to be identically equal with the lost kinetic energy, due to the motion of the stone.

We are thus led to the conception that, whereas matter may exist in many different forms, and whereas energy likewise may also exist in different forms, yet there is never within human experience any creation or destruction of matter, nor is there any creation or destruction of energy. When matter appears to be destroyed, it is merely passing from a more visible to a less visible form. When energy appears to be destroyed, it has merely passed into other forms less immediately obvious to our senses.

Hence we arrive at the conclusion, not only that matter and energy are the raw material of the Universe, but that the quantity of each is fixed and unalterable. The Universe consists of a certain definite and unchangeable quantity of matter and of energy; all that happens in the Universe consists merely of some alteration in the *form* of the matter or energy. From the widest point of view, the Universe exhibits a vast fund of matter and energy, undergoing changes of form, but not of quantity. Thus, in the course of time, matter passes from one form to another, energy passes likewise from one form to another. The fundamental fact of change—of a live Universe such as ours—is a redistribution of matter and energy. What we denominate events are no more than special cases, which may happen to interest us, of transformation of matter and energy. All the material of the Universe is given in a fixed quantity of matter and energy; all the changes or events occurring in the Universe are transformations of matter and energy from one form to another. We have now to consider separately these two groups of fundamental phenomena, and shall first turn our attention to the constitution of matter.

In the preceding chapter we dealt with magnitudes so great as to be far beyond the possibility of our imagination. We have now to deal with magnitudes so small as to be equally beyond the range of possible conception. We are to pass from the infinitely great to the infinitely small, and the strain upon our imaginative faculties will, if anything, be increased in so doing. For in the region of the infinitely great, we deal only with what is disclosed to us by the highest powers of the telescope. But in the region of the infinitely small, we pass far beyond the highest powers of the microscope. We are not to any great extent able to infer the existence of bodies beyond telescopic range; we are, on the other hand, able to infer with certainty the existence of bodies far beneath the limit of visibility, even with the most powerful microscope. In short, no microscope can disclose the existence of even the largest of the minute constituents of matter which we are about to describe.

To the naked eye matter appears to be continuous, more especially when it is in the solid or liquid states. This appearance, however, is due solely to our relatively low capacity of vision. In reality, matter consists of innumerable separate particles of incredible minuteness, and possessing rapid motion of several different kinds. These minute particles are called molecules. In a homogeneous portion of matter, all the molecules are identical in size, weight, and constitution. In the elementary forms of matter, their diameter is less than a hundred-millionth of an inch. In solids they are regarded as being so close together as not to admit of movement among one another, though each individual molecule has a vibratory motion of its own. In liquids they are still close together, but not so close as to prevent motion to and fro among each other. In a liquid, therefore, in addition to its vibratory motion, each molecule wanders about at large and is not confined to a permanent position. In gases, a far greater amplitude of motion is possible, and the distances between the molecules are considerable. In air, for instance, at normal temperature and barometric pressure, the molecules are all travelling on the average at about a thousand miles an hour—nearly as fast as a rifle bullet, and faster than the velocity of sound through air. Their motion takes place in all directions; and since they are incessantly colliding with one another, each molecule is constantly changing the direction of its motion. On the average, a molecule moves only three-millionths of an inch before colliding with another; and since their velocity is so great, the average number of collisions for each molecule is about six thousand million a second. The total number of molecules in a cubic inch of air is about 440 trillion.[1] One further dimension must be named before we endeavour to realize the meaning of these unimaginably small dimensions—namely, the mass or weight of the molecules. This, of course, is widely different with different kinds of substance. Normal air consists of nitrogen to the extent of more than three-quarters of its volume; and the weight of a molecule of nitrogen is of the order of one quadrillionth part of an ounce. The weight of a molecule of water would be still smaller.

In addition to their motion from place to place, the molecules in many cases rotate on their axes at inconceivable velocity. A few, such, for instance, as the molecules of argon (containing only one atom), are believed to have no motion

[1] It is necessary to observe that I use the words "billion" and "trillion" in their English, and not their American sense. By billion, I mean a million million; and by trillion, I mean a million billion.

of rotation; but in the majority this motion occurs. The hydrogen molecule, for instance, rotates on its axis about five billion times a second; and in general molecules are regarded as rotating not less than a million times in the thousandth part of a second.

These figures as set down are too minute to convey any sort of idea to the imagination. In order to realize them, however imperfectly, we must resort to an analogy. Supposing the amount of water that can be contained in a small thimble were magnified to the size of the entire earth, the molecules, which we should then be able to see, would appear about the size of footballs. They would be in close proximity to each other, though not normally in actual contact. If the thimble had originally been filled, not with water, but with a gas, such as air, and this quantity of gas were magnified to the size of the earth, the football molecules would then appear to be some ten or twelve feet apart from each other. Supposing their kinetic energy were magnified in the same proportion as their mass, then their velocity would remain the same, and they would all be in motion at a speed too great to be perceived by the eye, so that each football would present a mere streak as it travelled on its way, colliding several times a second with other footballs. Moreover, each football would be spinning on its own axis, in addition to its motion of translation from one point to another. If we assume that its kinetic energy due to rotation is increased in proportion to its mass, it follows that its angular velocity would be diminished in inverse proportion to the increase of radius; so that the footballs would be rotating on their axes at anything from once or twice up to several thousand times a second.

However difficult and imperfect such an analogy may be, it serves at least to indicate that matter is very different from what a casual inspection suggests. It is not continuous, as appears, but consists of an infinity of particles of incredible minuteness, revolving on their axes at inconceivable velocity, and dashing to and fro at a speed which the imagination cannot begin to realize. Moreover, as will shortly appear, the minute impenetrable particles of which matter consists fill only a very small part of the space which the matter seems to occupy. The interstices between them take up far more room than the particles themselves. For the molecules themselves are not continuous bodies like a football, but consist mainly of "interstices," with yet smaller particles wandering about in them. In short, it is believed that the volume occupied by actual material particles is less than one-millionth of the total space apparently occupied by a cold, solid body. A fragment of iron, for instance, consists simply of empty space in which the actual particles are flying about at relatively great distances from each other. This consideration introduces us to our next step in the analysis of matter—the question as to what is inside the molecules themselves.

Dalton's atomic theory, after being entertained as a provisional working hypothesis for about a century, has at length reached the position of being a practical certainty. According to this theory, the molecules consist, as a rule, of several particles still more minute than themselves, these smaller particles being called atoms. The atoms in a molecule preserve a certain distance from each other; but they are prevented by enormously powerful mutual attraction from exceeding these distances. Some molecules, such as those of argon, sodium, mercury, and zinc in gaseous form, consist only of one atom, and the atom then is the same thing as the molecule. Others, such as oxygen, hydrogen, nitrogen, hydrochloric acid, common table salt, etc., consist of two atoms. The molecules of carbon dioxide and of water have three atoms; that of ammonia four atoms; that of nitric acid five atoms; of sulphuric acid seven atoms, and so on. Inorganic substances are generally characterized by few atoms in the molecule; organic substances contain many more. Ordinary sugar, for instance, has a molecule of forty-five atoms, alcohol nine atoms, starch some multiple of twenty-one atoms, morphine forty atoms, while a dye such as helianthin (whose scientific name, by the way, is dimethylamidoazobenzenesulphonic acid) consists of thirty-six atoms in combination with a subsidiary molecule of water. Many organic molecules consist of a still larger number of atoms, and many are too large to admit of precise chemical analysis. Hæmoglobin, the pigment which gives blood its red colour, consists, according to one reckoning, in the case of Man, of about 1900 atoms, of which 600 alone are carbon.

Hitherto we have paid no attention to the fact that molecules are of as many different kinds as there are different kinds of substances in existence. The difference in molecules of different substances is due not only to the fact that they consist of different numbers of atoms, but also that these atoms are of different kinds. In all, there are believed to exist ninety-two different species of atoms. Some of them are very rare; some have scarcely yet been discovered at all; but from other considerations, it is known that the total number of different kinds of atom in existence from hydrogen to uranium must be ninety-two.[1] Their main distinction is in their weight; but their chemical properties also are widely different. When a molecule is made up of one kind of atom only, the substance is called an element; where it includes atoms of different kinds, it is called a compound. Thus hydrogen, nitrogen, and oxygen each consist of two similar atoms, and are, therefore, elements. Ozone consists of three atoms (of the same kind that make up oxygen). Arsenic and phosphorus are elements, each containing four similar atoms.

Water, on the other hand, consists of two hydrogen atoms and one oxygen atom, and is, therefore, a compound. Table salt consists of one atom of sodium and one atom of chlorine,

[1] These ninety-two kinds represent ninety-two different *types* of atom, rather than individual homogeneous things. It is now known that each type may include several different varieties or "isotopes."

and is a compound. Ammonia is a compound of one nitrogen with three hydrogen atoms; sulphuric acid of two hydrogen, one sulphur, and four oxygen atoms, and so on. Organic substances are invariably compounds, in which there is always at least one carbon atom present. All forms of matter, therefore, solid, liquid, and gaseous, are built up out of the ninety-two different kinds of atoms. Substances are different because their molecules are different; and molecules are different because they contain different numbers of atoms, different kinds of atoms, and because the atoms occupy different relative positions within the molecule.

We have now to look more closely at the atoms themselves, and ascertain some idea of their properties and dimensions. In the first place, it is clear that the bond of union which holds them together in the molecule must be extraordinarily powerful. It has already been mentioned that the molecule of hydrogen is spinning on its axis at the rate of five billion times a second. This involves a vast disruptive tendency on the atoms, owing to the centrifugal force which acts powerfully towards driving them asunder. To resist this centrifugal force, the tenacity of the bond between them must be at least a thousand times greater than that of steel; in some cases the stress required to separate them would be many tons to the square inch. The diameter of the atom is of the same order as that already named for hydrogen molecules. A molecule consisting of two atoms may possibly be regarded as something like a dumb-bell, except that in the case of atoms the connecting link is not material, but represented by their vast cohesive force. An important difference between atoms, as already stated, is that of their weight. The lightest atom is the hydrogen atom. We have already observed that the weight of the nitrogen *molecule* is of the order of one quadrillionth of an ounce. Since there are two atoms in the nitrogen molecule, the weight of the nitrogen atom would be just half this quantity. The weight of the hydrogen atom is about one-fourteenth of that of the nitrogen atom. The heaviest known atom is that of uranium, which weighs nearly 240 times as much as hydrogen. Between hydrogen and uranium are ranged all the rest of the ninety-two atoms, forming a scale of weights that increase in more or less regular order. Indeed, it was long ago discovered by Mendelejeff and Meyer independently that atoms, or rather elements, exhibit a regular sequence, not only as regards weight, but as regards chemical properties. At that time many of the elements were still undiscovered, and even their existence unsuspected; but the classification of Mendelejeff was found to contain a number of gaps, and the prophesy was then made that elements would some day be found to fill those gaps. Thus the existence of the metal gallium was prophesied by Mendelejeff in 1871, but actually discovered only in 1875. He not only prophesied correctly its atomic weight, but also its melting-point, its specific gravity, and many of its chemical properties. The existence and properties of scandium (discovered in 1879) and of germanium (discovered in 1886) were similarly predicted. The element helium found a place in the Periodic Classification, though it had not at that time been discovered on the Earth. It had, however, strangely enough, been discovered in the Sun by means of the spectroscope, and its discovery on our own planet was not effected till long afterwards, in 1895.

Throughout the nineteenth century it was supposed that atoms were the smallest particles of matter that existed, and that they were indivisible. This belief, indeed, was usually incorporated in the statement of the atomic theory. It was, however, an entirely inessential part of that theory; no conclusions were based upon it, and no arguments (other than metaphysical) were drawn from it. It was expressed, not as established theory, but as speculative hypothesis which future learning might or might not determine to be correct. There were, in fact, many, even early in the century, who believed that the various types of atom were all built up from one primordial form of matter. The twentieth century has completely vindicated this belief. In so far as the existence of molecules and atoms is concerned, it has raised the status of the atomic theory from that of a mere working hypothesis to that of an established doctrine. On the other hand, it has shown with equal clearness that the atoms are not indivisible, nor yet the ultimate basis of matter. Just as molecules are made up of a varying number of atoms, so atoms are made up of a varying number of yet more minute particles—particles so inconceivably minute, that as we examine them we at length perceive matter, apparently so solid and resisting, actually fade away altogether and vanish into nothing. We pass on, therefore, to consider the internal structure of the atom.

The old conception of the atom as a hard and solid fragment of indivisible matter has given way to its conception as an empty sphere of space, in which exist a varying number of particles, whose minuteness is such as to preclude any possibility of description. These particles are termed electrons. Their diameter is regarded as about $\frac{1}{65,000}$ that of a hydrogen atom. That is to say, if an atom were magnified to appear of the size of a large room in an ordinary house, the electrons within it, on the same scale, would be only just visible to the naked eye; and if one of them were lost, it would be almost hopeless to attempt to find it again. Their weight is likewise infinitesimal—according to the most recent determinations it is $\frac{1}{1850}$ of the weight of the hydrogen atom. The comparison of the electron to an atom of oxygen would resemble the comparison between an ounce and a ton. Great as the contrast in weight seems to be, it is not nearly so great as the contrast in volume.

Electrons are found to be precisely identical, from whatever kind of matter they arise. There are not among them any varieties, such as exist among the atoms, and since atoms are built up out of electrons, it is clear that the varieties of atoms must be due to a difference in the number of electrons which they contain. Now as we pass along the series of the ninety-two different varieties of atoms, in the order of their increasing weight, it is believed that each atom contains one more electron than the atom which immediately precedes it. Thus hydrogen, the lightest of the elements, would have an atom containing one electron. Uranium, the heaviest, would have an atom containing ninety-two electrons. Nitrogen, being seventh on the list in the order of ascending atomic weights, would have seven electrons to the atom, and oxygen, which fills the next place, would have eight. In all these cases, the complexity of the atom may be increased by a number of additional electrons contained within the nucleus. Thus all the elements from which all forms of matter are compounded are built up from one single kind of unit, aggregated into atoms of greater or lesser number of those units.

The most important property of the electron, however, still has to be named. It carries an enormously powerful charge of negative electricity. The various particles of matter, hitherto mentioned, have been electrically neutral; but the electron, by far the smallest of them all, carries an electric charge greater than any other known within the limits of human experience. If it were possible that small particles of matter, just visible, should carry corresponding charges, and if two such small particles could be placed in contiguity, the force of repulsion between them would amount to countless millions of tons.

The electrons, nevertheless, are held together somehow within the atom. It is, therefore, assumed that there exists in the atom a central nucleus, consisting of a positive electrical charge, of an amount that is equal to the sum of the charges on the electrons. For reasons about to be mentioned the diameter of this central nucleus must be far less even than the diameter of an electron. It is by far the smallest measurement known to science; so small, indeed, that for many purposes it may be regarded as a mere geometrical point. It is probable that the electrons revolve in circular orbits round the central nucleus and that the atom thus resembles a miniature solar system, with planets revolving round a central sphere of attraction. If this be the case, then it turns out that the infinitely small and the infinitely great are arranged upon a common plan. Summing up the conception of matter thus far attained, we find it to consist, in a final analysis, of a planetary system of electrons and nucleus. The differences in the number of electrons (and hence of the charge on the nucleus) give rise to ninety-two different kinds ot atoms. These atoms, compounded with each other in numberless different ways, produce the molecules from which all the different kinds of matter are built up.

At length, therefore, we are in a position to approach the problem, what is matter? It resolves itself into the problem, what are electrons, and what is the central nucleus? We defined matter at the outset as that which possesses inertia, that is to say, a resistance to any change in its state of rest or motion. Nearly forty years ago it was pointed out by Sir J. J. Thomson that a sphere charged with electricity must possess a somewhat greater inertia than an equal sphere not so charged. For all ordinary magnitudes, the difference is so slight as to be incapable of detection by the most sensitive instrument; but the very remarkable principle was established that inertia might be due, not only to mass, but also to electrical charge. It is suggested that a body is actually heavier when charged with electricity than when electrically neutral. When the body is moving at low velocities, the electrical inertia is very slight, but it increases with the velocity of the body, until at velocities approaching that of light it becomes a very considerable factor in the total inertia of the body.

With bodies of ordinary magnitude, there can be no approach to any such velocity as that of light. But an electron is not a body of ordinary magnitude. Not only is it inconceivably small, but it carries an inconceivably immense charge of electricity, and it is often found to travel at an inconceivably high velocity. The main peculiarity of radium, and other radio-active elements, is that their atoms are disintegrating, and the electrons shot forth into the surrounding space. The velocity at which they are driven out is often higher than 150,000 miles a second. Whether as regards size, or as regards electrical charge, or as regards velocity, the electron is fundamentally different from any of the magnitudes ordinarily dealt with. The interesting question arises, therefore, as to how far the inertia of an electron is due to its mass, and how far to its electrical charge. The problem has been solved: the whole of its inertia is due to its charge; there is none left over that can be attributed to its mass. But since inertia is the one distinguishing character of mass—that is, of matter—the discovery is tantamount to the statement that an electron has no mass—that it is not matter at all, but simply a charge of electricity suspended without bodily support, though having a definite, if exceedingly minute, diameter and volume.

As regards the positively charged nucleus of the atom, the same astonishing fact has not yet been substantiated by any definite proof. It appears highly probable, however, that the nucleus is also a disembodied electrical charge. If that is the case, its diameter must be a small fraction of the diameter of the electron. The mass of the atom is certainly due almost wholly to the nucleus, whose weight, therefore, must be nearly two thousand times that of an electron. The charge carried by the nucleus is necessarily equal to that carried by the attached electrons. The electrons in an atom are far too few to account for its known weight; and if that weight is entirely due to electrical charge on the nucleus, such charge must attain a far higher degree of concentration even than the charge on an electron. This supposition requires us to regard the actual volume of the nucleus as proportionally smaller than the volume of the electron. Charges being the same, the necessary concentration on the nucleus can only be achieved by reduction of its diameter.

Let us now, at the conclusion of this analysis, revert to our former analogy, to see what matter would look like if magnified to, say, a thousand million diameters, so that the contents of a small thimble appeared to become the size of the earth. Even under this great magnification, the individual electrons would still be too small to be seen by the naked eye. Small aggregations of these invisible electrons, moving in invisible orbits round a centre, would be aggregated to form atoms, and these again to form molecules, appearing (if they could be seen) to occupy about the same volume as a football. The first circumstance that strikes us is that nearly the whole structure of matter consists of the empty spaces between electrons. Matter, which appears to us so continuous in its structure, is really no more than empty space, in which at rare intervals here and there an inconceivably minute electron is travelling at high velocity upon its way. It ceases, therefore, to be remarkable that X-rays can penetrate matter and come out on the other side. How should the tiny electrons obstruct their passage? It ceases to be remarkable that an electron from radium can be shot clean through a plate of aluminium; for, from the electron's point of view, the aluminium plate is very little different from empty space. And if a thimbleful of solid substance were magnified to the dimensions of the earth, the curious circumstance is that we should actually see nothing at all. The electrons would still be too small; we should see only the interspaces, which are relatively so great as to occupy apparently the entire field of view. Clearly, matter is very different from what it appears at first sight to the unaided vision and the uneducated mind.

The doctrine that matter ultimately consists of disembodied electrical charges appears to many people so inconceivable, and so far removed from common sense, as to be altogether incredible. We appear to have passed beyond the region of physics into that of metaphysics, where paradox and magic take the place of solid fact. Nevertheless, we are bound to follow out the results of physical experiment and deduction, to whatever incomprehensible conclusion they may lead us. We must not be trammelled by the narrow limitations of "common-sense," which, after all, has only developed within us through contact with the world we know, and may be utterly misleading if carried with us into the utterly new world which we are trying to explore—the world of the infinitely small. On such a voyage of discovery we must shed our prejudices at the start; they belong only to the common world we know; we must leave them behind, and follow the guiding light of physics into whatever astounding mysteries it may lead us. When at last we find ourselves standing in the midst of a stranger land than our imaginations ever dreamt of, it is wiser to condemn the former limits of our imagination, than to question whether this land really does exist. It certainly does; that at least is by far the most probable verdict of physics. If it is difficult to realize, the error is more likely to be due to the feebleness of our imaginative faculties than to any doubt as to the real facts.

But are the facts, after all, not capable of being brought within our imagination, after it has been stretched somewhat and freed from the rigidity of convention and habit? The main obstacle to be overcome is the resolution of matter into disembodied electrical charges. All our former experience of electricity teaches us to regard it as a particular state of matter. We find it hard to conceive a charge of electricity apart from a portion of matter, on which the charge resides. It seems much like speaking of an actual motion without any moving body. Yet there are phenomena within our ordinary experience which present a tolerably complete analogy. Electricity is one form of energy; and we are familiar with other forms of energy which have no material substratum. Such a form of energy is light, which traverses empty space, and works its effect on our sense-organs without any basis of matter whatever.

It is a form of energy which, like the electron, occupies space while yet wholly immaterial. As to whether light has inertia—whether it has an actual weight, like the electron—is not yet determined. The question is likely to be determined by the observations taken during the recent solar eclipse; but the result is not known at the time of writing.

So, also, radiant heat has no material basis. Light and heat are transmitted to us from the sun, and travel across space at a velocity that would be impossible if they were tied up to even the smallest particles of matter. True, the current theory of radiant heat and light is that they are undulations; and since it is hard to imagine undulations without anything to undulate, the universe is regarded as being filled by an all-pervasive æther, 700,000 times more elastic than air. But this æther, whatever else it may be, is not matter. The properties which it must possess if it is to account for the facts for which it was invoked, could not possibly exist together in matter. It must have a rigidity greater than that of steel; it must have a density many million times greater than that of lead, and yet it must be so attenuated that the stars and planets can fly through it at huge velocities without the smallest sign of retardation or friction. Such a collocation of properties is certainly not compatible with our conception of matter. Thus radiant energy exists apart from any basis that we should recognize as matter; and if radiant energy undoubtedly so exists, why should not electrical energy also in the form of an electron?

Psychologically also, there is little reason for astonishment. Matter, as will be hereafter explained, is not an immediate datum of consciousness, but an inference. All we have immediate knowledge of, without inference, is our sense-impressions. All knowledge, save that of direct sense-impression, is derived by the methods of generalization and deduction. We know that in the case of light and heat sense-impression may be produced by energy alone apart from matter. If some sense-impressions are so produced, no difficulty remains in supposing that they may all arise in the same way. *Il n'y a que le premier pas qui coûte.* Every physicist admits that *some* inertia is of electrical origin. But in doing so, the principle of immaterial inertia is conceded. Logically there can be no objection to supposing that the whole of inertia may be due to the same origin. The ordinary induction of electric currents may make the difficulty seem less.

The tendency of recent physical science, then, is to obliterate the distinction between matter and energy. The Universe no longer seems to be occupied by two fundamentally different forms of existence. It is simply the seat of electrons, which give rise to what we know as matter and energy, manifesting themselves in a great variety of different forms. True, we still have a dualism at the root of all phenomena. If it is no longer the dualism of matter and energy, it is that of positive and negative electricity. But the contrast between these two is far more easily bridged by the mind than the contrast between matter and energy. They are the same *kind* of existence; the same laws apply equally to both; their effects upon the neutral environment are in all cases identical. We have approached, by this doctrine, far nearer to the complete unification of knowledge, which has long been the goal of philosophy.

We pass now from the consideration of matter to that of energy, in its normal and recognized form. The most fundamental law of energy, as already stated, is that of its permanence. Like matter, it is capable neither of being destroyed nor created, but only of changing its form. Light can change into heat, heat into electricity, electricity into motion, and so on; but the sum-total of the energy remains unaltered. For every disappearance of energy in one form, there is a fresh and equivalent appearance of energy in some other form. All these forms of energy can ultimately be resolved into some kind of motion. Heat, for instance, is molecular motion. The difference between a hot body and a cold body is merely this, that in the hot body the molecules are vibrating more rapidly than in the cold body. So that if kinetic energy—*i. e.* the energy possessed by a body in virtue of its motion—is transformed into heat, what really happens is that the motion of the body as a whole is converted into motion of its individual molecules. In the same way, the electric current is the motion of electrons. The current consists of a stream of myriads of electrons flowing at huge velocities. In an ordinary sixteen-candle-power electric lamp, the number of electrons passing through the filament each *second* is so great that, if the entire population of London were told off to count them, and if they counted at the rate of two a second, without ever stopping day or night, it would take them ten thousand years to complete the task.

Sound also is motion—a vibrating motion of the molecules of air or other substance through which the sound is conducted. Light is regarded as a vibratory motion of the same character, conducted by the æther. In short, all forms of energy may be regarded as motion; and all the phenomena of physics can be represented in terms of matter and motion. One proviso indeed has to be made. All the above-named forms of energy are *kinetic*—they imply something or other that is moving; but there is another species of energy, named *potential* energy, in which nothing is moving, nothing happening at all. If a stone is thrown up into the air, and falls upon the ground again at the same level from which it was thrown, the sudden destruction of its motion on reaching the Earth gives rise, as already remarked, to heat, sound, light, etc., equivalent in amount to the lost energy of motion. But if it does not fall down again—if, at the height of its path through the air, it lands, for instance, upon a ledge of rock, no fresh manifestations of energy are set up. Its kinetic energy of motion is lost at the height of its trajectory; it comes lightly or imperceptibly to rest on the ledge, setting up very little heat or other phenomena of energy. What has happened to the vanished energy of its motion?

In point of fact, it *has* vanished as regards any actual form. All that remains is a latent power to give out again the same amount of energy that is apparently lost. The stone may rest upon that ledge for an indefinite period, but if the ledge is some day removed, the stone, in falling to its original level, will give out precisely the same amount of energy originally conveyed to it when it was projected by the thrower. From the point of view of the thrower, energy vanished out of existence when the stone came to rest upon the ledge. From the point of view of the man who, perhaps centuries later, removes the ledge, energy suddenly develops, apparently out of nothing. When, therefore, we speak of the permanent indestructibility and uncreatibility of energy, we are not referring solely to kinetic energy, which implies something actually moving; we include also potential energy, where nothing whatever is occurring, but where, under certain circumstances, we know that actual energy may be produced, and we can prophesy the exact quantity of it. In such cases the energy is not destroyed; it is in abeyance only. It is spoken of as stored energy or locked-up energy, which by suitable means can be reconverted into live energy once more.

There are many forms of potential energy besides that named above, which is energy due to position. A compressed spiral spring, for instance, possesses potential energy; so, also, a compressed gas or a stretched piece of elastic. Chemical affinity is a form of potential energy. The radiant heat and light of the Sun falling upon the Earth many ages ago were caught up and entangled by the then-existing vegetation, and used for building up large complex organic molecules out of simple inorganic molecules. The radiant energy is stored in these organic molecules, until the vegetation petrifies into coal. By burning the coal, the energy which has for so long been locked up is given forth afresh in its original form of heat and light.

Energy, therefore, cannot be regarded as an actual existence or a thing, notwithstanding that it endures permanently and is amenable to precise quantitative measurement, and, indeed, is bought and sold at fixed rates for commercial purposes. It has many analogies with a thing, but it is not a thing; for it can pass out of real existence, leaving no trace behind it except the power to return. In the last analysis it may, perhaps, be defined as that which, under given circumstances, is capable of setting up a sense-impression within us. Reduction of all phenomena to sense-impressions is the climax of scientific effort.

Energy is generally regarded as consisting of two components—an extensity factor and an intensity factor. Thus, the energy of motion is made up of the momentum or "quantity of motion" of the body in question and its velocity. The product of these two gives the kinetic energy. Electrical energy is derived from the "quantity of electricity" and the potential. Heat is derived from "entropy" and temperature. The same two factors are found in all forms of potential energy; thus the energy of position is compounded from the weight and the height of the body concerned. This mode of regarding energy as the product of two factors does not appear to lead to any very interesting results, with the possible exception of this: that there seems to be a general tendency throughout the Universe at present towards a diminution of the intensity factor of energy, and a consequent increase of the extensity factor. This circumstance may now introduce us to one of the deepest and most significant of the wider laws of philosophical physics.

We have pointed out that the sum-total of matter and energy in the Universe remains unaltered. Everything that happens is comprised in a mere redistribution of matter and energy, matter changing from one form into another, energy likewise changing its form, but the actually existing *quantity* of both remaining constant. The question now arises whether these transformations of matter and energy are equally ready to take place in any direction, or whether they seem on the whole to be tending towards a goal in one particular direction. If transformations of matter and energy are entirely reversible, taking place with equal facility in any direction, then the Universe might be regarded as a permanent existence, in more or less its present form. There would be no reason for supposing that it could ever have had a beginning, or that it would ever have an end. But if the transformations, or (stated more simply) the events occurring in the Universe, take place on the whole in one direction rather than another, then there must ultimately be reached, if the process continues, an end to the Universe as we know it; and, by similar reasoning, there must, at one time or another, have been a beginning.

The progress of physics has not left the matter in any doubt at all. Transformations do *not* take place equally readily in all directions; they tend very unmistakably towards what may be called a degradation of matter and energy. The Universe is running down; and, theoretically at least, a time may be imagined when it will have run down altogether, becoming still and "lifeless." As regards energy, this fact was discovered many years ago; as regards matter, the discovery is very recent; we shall, therefore, deal first with energy.

In every transformation of energy from one form into another evolution of heat takes place. At every conversion of kinetic into electrical energy, or electrical into kinetic energy; of electrical energy into light; of light into chemical energy, and so on, some wastage takes place in the form of heat. In all conversions of energy in practical life, a leakage of heat occurs throughout the process. If, for instance, we desire to illuminate a house by the usual method of converting an electric current into light, however perfect our installations, the amount of light obtained is always, and necessarily, *less* than the full equivalent of the electrical energy supplied. And the reason is this, that part of our electrical energy inevitably goes into heat, and is not, therefore, entirely available for conversion into light. Every energy-conversion is, as it were, attended with a friction, so that part of the original energy is dissipated in the form of heat, while only the remainder is available as utilizable energy. The amount of heat-leakage varies widely in different machines. The ordinary steam-engine, for instance, is a machine for converting chemical into kinetic energy. The chemical energy is contained in the fuel supplied to the machine. By burning the fuel, the chemical energy is changed into heat; the heat again is changed into pressure of steam; and the pressure into kinetic energy or mass motion. But the motion thus obtained through the steam-engine is far less than the original energy supplied to it as fuel. During the processes of transformation, at least 80 per cent. of the original energy radiates away as heat, leaving only the remaining 20 per cent. to be applied to the purpose for which the steam-engine was constructed. In other kinds of machines, as, for instance, a dynamo, the heat wastage may be reduced to less than 10 per cent. of the original energy; but in every artefact machine, and in every case of energy-conversion in Nature, some part of the original energy goes into the form of heat. This effect is not to be regarded as due to any "imperfection" in the processes of energy-conversion. It is, on the contrary, one of the most fundamental of the laws of Nature. The dissipation of energy as heat is as essential a factor in natural processes as are inertia and friction. Heat, so to speak, is the lowest-grade form of energy, to which all other forms tend gradually to fall.

It was remarked just now that all forms of energy have an intensity and an extensity factor. In the case of heat, the intensity factor is what we know as temperature; the extensity factor is called "entropy"—a mere abstraction, representing no actual objective phenomenon. Since a body at high temperature tends to convey heat to a body at low temperature, and since a body at low temperature cannot, under any circumstances whatever, convey heat to a body at higher temperature, there is a further tendency to universal equalization of temperature. So that the increase in the total quantity of heat does not make its appearance so much as regards the intensity factor of temperature, but as regards the extensity factor of entropy. This is expressed in the statement that the final goal to which the Universe is tending is that where entropy reaches a *maximum*. In simpler words, all forms of energy are undergoing gradual degradation into heat; and the heat so produced tends to spread itself at a level temperature throughout the entire confines of the Universe. The goal to which the Universe is slowly progressing is a condition in which no further available energy is left, nor any differences of temperature, but a relatively still, lifeless, inert, *cool* aggregation of matter.

After ascertaining that energy tends to a final state of universal degradation, the question naturally arises whether there may not be any corresponding process to be discovered as regards matter. Does matter, like energy, tend to a lifeless equality throughout the Universe? In this connection we have to consider, not the molecules, but the atoms. On the Earth, at the present time, molecules are perhaps as complex and as varied as they have ever been. But the molecules of highest complexity are those found in living organisms, and are, therefore, purely ephemeral. In a greater or lesser number of years, these complex molecules break up into simple molecules once again ; they have no stability or permanence; for in such periods as we have to consider, a few years, even a few ages by human reckoning, scarcely constitute a fleeting second in the onward march of time. Inorganic molecules likewise have only a relative stability. Even in an ordinary chemical laboratory they can all be broken down into the different elements of which they are composed. The question of the permanence of matter, in its present form, is therefore the question of the permanence of the ninety-two different kinds of atoms of which all matter is composed.

Until recently, it was imagined that atoms were characterized by complete permanence and stability. Modern researches in radio-activity have altogether dissipated this belief. Sundry different atoms have been found to be in a state of disintegration. Atoms are composed, as already explained, of a varying number of electrons, and in those atoms which are disintegrating, single electrons are shot forth into space, the atom which remains being thereby a smaller and less complex structure than the original. The atoms known to be disintegrating are the largest and heaviest among the series of ninety-two. The largest atom of all—that of uranium—is very slowly breaking down to form a smaller and lighter atom, that of radium. The speed of its disintegration is invariable, and cannot be altered or affected in the slightest degree by any agency known to man, or in whatever circumstances it may be found. The total quantity of uranium on the Earth is diminishing, and the most complex of the elements is thus slowly but inexorably vanishing from our planet. Radium itself is still a very heavy atom, but it, too, is breaking down, even faster than uranium. Supposing no fresh radium were formed, the total amount of it now on the Earth would be reduced to one-half in less than 2000 years. Radium, on breaking down, gives rise to various new products of highly unstable character. They are all more or less ephemeral, having an average life varying from a few years to a few minutes. As these, one after the other, break down, the simplified atom that remains at the end is no other than the atom of the metal lead. It is about 13½ per cent. lighter than the uranium from which it was derived.

The chief popular interest of this astonishing discovery has been in the proof which it afforded of an actual transmutation of the elements. It is genuine alchemy going on in Nature, though an alchemy which no human agency is competent either to accelerate or retard. For our present purpose, however, its main interest is in showing that, on the Earth, matter is undergoing a gradual simplification. All known elements heavier than lead are disintegrating.[1] The quantity of them upon and within the Earth is diminishing by an apparently irresistible law. Nor is there any reason to suppose that this degradation of matter is in progress only among the heaviest atoms, where its operation is the most easily discerned. A feeble radio-activity has been discovered in comparatively light and simple atoms, such as those of potassium and rubidium. Lately even nitrogen has been found to disintegrate, with the formation of hydrogen atoms. There is very good reason for the suspicion that all the known elements may be breaking down into simpler forms. The disintegration of radium proceeds, not only by ejection of electrons from the atom of radium, but also by ejection of intact atoms of helium, which, after hydrogen, is the lightest known atom. One ounce of radium throws out these helium atoms at the rate of over a thousand million a second. They are ejected with prodigious force at a velocity often greater than ten thousand miles a second, and may travel through

[1] Except bismuth, which is almost the same weight as lead.

two or three inches before they come to rest. The internal explosion by which these helium atoms are driven forth is inconceivably more violent than anything of the nature of human explosives. The transformation of a single ounce of radium into its end-products would give out as much heat as would be generated in the combustion of fourteen tons of coal. It is little wonder that these colossal forces are beyond the control of laboratory methods.

The phenomena of radio-activity have only been studied on the Earth; and it does not follow that, because on the Earth matter is tending to simplification and loss of variety, the same processes need be taking place in other parts of the Universe. On the contrary, it seems quite probable that at the centres of many stars, where the pressure and the heat are fabulous in their immensity, a regeneration of atoms may be in progress, and a reverse process to that occurring on the Earth may be taking place. But the stars also are radiating their heat into space; in course of immense ages they cool down, they reach the phase in which we find the Earth at present, and they continue onwards to the coldness of death. It may well be imagined, therefore, that a similar degradation of matter will then take place in them also. As heat radiates away into space, matter becomes more and more degraded, until, when all the energy of the Universe is reduced to an equal and inert level of heat, matter itself would also have assumed a form very different from that in which we now know it.

It will be interesting to mark the final goal to which all these natural processes are tending. There is, indeed, not the smallest reason to believe that this goal will ever be reached. Our observations are limited to portions of space and time that are infinitesimal by comparison with the spaces and times in the life of a universe. Moreover, innumerable other factors must be at work to modify or reverse the tendencies which we can witness. While, therefore, it is not within the horizon of humanity to prophesy an end to the Universe, it is nevertheless legitimate to point out the end to which all things appear to be moving in the present state of our knowledge and under the extraordinary limitations of our observation. For things do appear to be moving to a goal. The Universe is not reversible, it cannot move backwards as well as forwards; it seems to approach an end, when both matter and energy shall have reached their final stage of degradation. Their gradual approach to that end is not such as to suggest that it can ever actually be attained. It is an end to which we slowly draw nearer, without ever reaching it, as the curve of a hyperbola draws always nearer to its asymptote. The final goal can never be reached, because the time taken to arrive there is too inconceivably great even by the standards of Astronomy. It is, in short, an infinite time that would be required.

But this goal, which can scarcely be the true goal, and which (if it were) could never be absolutely attained, represents a condition in which both matter and energy have reached their last degree of degradation. Energy would be distributed with absolute equality throughout every corner of the Universe, in the form of heat where there was nowhere any variation of temperature. Matter would consist only in the form of the simplest known atoms, such as those of hydrogen or of helium. Since heat is simply molecular motion, the Universe would then consist only of these primitive atoms in a state of vibration. But is it to be supposed that even the most primitive atoms are eternally stable? Such an atom consists typically of a charge of negative electricity revolving at immense velocity around an equal charge of positive electricity. Suppose that in course of unimaginable ages there occurs some retardation in the velocity of the negative electrons, as indeed occurs with planets revolving round a sun. What would happen then? The same as happens in a solar system, where the planets at length fall in upon their central nucleus of attraction. The electrons would fall in upon the positive nucleus, and there would remain—nothing whatever, no trace left of either energy or matter. For the negative charge, of which the electrons consist, precisely neutralizes the positive charge of which the nucleus consists. All electrical phenomena would instantly vanish; matter and energy would be extinct; the void which remained would be just as though no energy and no matter had ever previously existed. At the same moment, all relations of space and time would be gone. The Universe would have "gone out" more completely than anything we can understand, leaving not even a part of space of which it might be said that here the Universe once existed; not even a period of time during which it might be said that the Universe was a real thing.

A few words may be added here concerning the relationship to philosophic materialism of modern views as to the constitution of matter. These modern views are in every particular consonant with materialistic interpretations; they are in every particular irreconcilable with spiritualistic interpretations. Penetration into the secrets of atomic structure has opened up to us a vast new sphere of phenomena whose very existence was previously unsuspected, and which differ *toto cœlo* from all kinds of phenomena with which we were previously acquainted. Yet throughout this new continent of knowledge we find the axioms of materialism as unquestioned as ever. The electrons and the positively charged nuclei of atoms have their unchangeable laws, and illustrate afresh the inviolable relation of cause and effect. Nor, as we approach the very foundations of existence, do we see any more signs than elsewhere of a *purpose* at the basis of the Universe. Harmony and order, certainly: that arises from the universality of natural law; it is the same kind of harmony and order that prevails in the larger material masses of the Universe. Even if the Universe is running down to a final doom of extinction, there is no suggestion of purpose there. A clock also runs down, but not by previous intention—not for what we understand as a purpose. Finally, in this new field of discovery there is no place for any kind of spiritual agency. We know at length what is the basis of matter: it is not spirit, it is energy, a factor exclusively objective in character, and residing on the materialistic, not on the spiritualistic plane. It may be suggested that materialism is no longer a suitable name for a doctrine which dissolves away all matter into intangible energy. The contention cannot be upheld, however. Scientific materialism has never imagined matter to be as it seems to the unaided touch and vision; and into whatever factors it may be analyzed, it remains matter in the only sense knowable by us. Heat is none the less heat that it consists in molecular vibration; light is none the less light that it is an electro-magnetic manifestation in space; nor is matter any the less matter in that it may be resolved into energy or even into nothing. It remains the prototype of all that class of phenomena; and materialism in consequence remains the most suitable name for the philosophy which embraces it.

Furthermore, one thing is certain. Whatever matter may ultimately be resolved into, it certainly cannot be resolved into spirit. The wildest speculator in science has never suggested *that* possibility. And the name materialism only has a meaning by contrast with the rival doctrine of spiritualism. We may, indeed, note the astonishing range of materialistic explanations, as compared with those put forward on the spiritualistic side. These latter adopt the commonplace experiences of ordinary life, and transfer them indiscriminately to a new region. Whenever a difficulty arises, spiritual agency is invoked to explain it. All things are regarded as the product of a magnified but still quasi-human intelligence, working by quasi-human, or usually wholly human, motives. This single idea is monotonously repeated as often as the need of explanation is felt, whereas under the materialistic philosophy a stream of fresh conceptions of unimagined novelty continues to flow. The wonders and the miracles of theological cosmogonies become dull and commonplace by comparison with the materialistic statement of the actual facts. But, in truth, spiritualism has long been driven from the sphere of the inorganic. Its last refuge is in the sphere of life and consciousness, to which accordingly we shall now turn our attention.

CHAPTER III

LIFE AND CONSCIOUSNESS

We have investigated two out of the three fundamental classes of phenomena which appeared at our first inspection to make up the Universe. We have found that these two—matter and energy—are ultimately reducible to one. We now turn to the third, in order to ascertain to what extent, if any, it differs from the other two. *Primâ facie* the phenomena of life and consciousness would appear to be in an entirely different category from the phenomena already described. Realities, however, are very different from *primâ facie* appearances. Just as we found that matter and energy are fundamentally different from what an uneducated opinion imagines, so we must be prepared to find that life and consciousness can be analyzed into altogether unexpected elements. Unfortunately, prejudice in this sphere is far more universal than in that hitherto dealt with. Many—most people in fact—start with a rooted determination that life and matter are essentially and necessarily distinct from one another. They hold this belief before they begin to inquire into the subject, and they hold it with such tenacity as to close their minds to all contradictory evidence. If the reader is determined to harbour that particular opinion, let him harbour it, and save himself the effort of investigation. There is no compulsion upon him to ask further on a question where his mind is already made up. If, on the other hand, he really desires to know the truth of things, let him dismiss all bias and start with a genuinely open mind, remembering that science very rarely bears out the first conclusions formed by the uninstructed imagination.

We have found that there exist upon the Earth ninety-two possible different kinds of atoms, and that from the different combinations of these atoms, all the different substances on the Earth take their origin. We found that the inorganic substances are aggregates of molecules, consisting for the most part of comparatively few atoms. Organic substances, on the other hand, are aggregates of molecules, containing usually a far larger number of atoms, and they have the further characteristic that among these atoms, the atom of carbon is invariably present. For this reason, organic chemistry is, in reality, the chemistry of the carbon compounds; and the highly complex compounds characteristic of carbon have properties correspondingly more complex than those of simpler compounds.

Of all the carbon compounds, the most complex are those which constitute the group called protoplasm. So complex, indeed, is this class of substance, that it has not yet been given any precise chemical formula. It is known, however, to be a congeries of substances, of somewhat different constitution, and not a single fixed compound. The elements of which it consists are chiefly carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorus, sodium, potassium, chlorine, calcium, magnesium, and iron. No element enters into its composition except such as are quite common in the inorganic world. The most essential and invariable constituents of protoplasm are the proteins, the molecules of which are known to be of immense complexity, consisting certainly of hundreds, possibly of thousands, of individual atoms. These protein molecules each appear to be systems of smaller molecules, united together. In the same way, it is conceived that the physico-chemical unit of protoplasm may be a system of protein molecules held together, in conjunction, perhaps, with molecules of carbohydrate or fat. Protoplasm is a name, not for one substance, but for a class of substances, and the special interest attaching to this class of substances, is that out of them the living tissues of animals and plants are built up.

Protoplasm is found only on or near the surface of the Earth. As a highly complex substance, it is rapidly disintegrated by heat into its components, and its formation occurs only within narrowly defined conditions. Corresponding to its elaborate chemical constitution, its physical and chemical reactions are likewise elaborate. All the manifestations of living organisms, in short, are expressions of the chemical reactions of protoplasm. This extraordinarily complex and varied group is found upon the Earth in a very large number of different types. These types form the foundation of what are called species; and we now turn to a consideration of what actually constitutes a species.

No two individuals, either animal or plant, are precisely identical. But, on the other hand, no individuals are found that do not bear a close resemblance to numerous other individuals. It is thus possible to draw up a *classification* of animals and plants, based on their resemblances. The unit of such classification is the species, consisting of groups of organisms all similar to one another in essential details, and differing only in those *minutiæ* by which individuals are distinguished. Naturalists do, indeed, establish groups still narrower than species; they classify organisms into subspecies and into varieties, but with this we are not now concerned. When all animals are divided into species, it is found that some species resemble one another more than others, and a number of similar species are bracketed together to form a genus. So, too, genera are combined to form families, families to form orders, and orders to form classes, so that the animal and plant kingdoms are divided into a comparatively small number of classes, which comprise all living organisms within them.

These various divisions of animate nature have no real existence as objective things. They do, indeed, represent the family relationships of living beings, but one of them represents still more. A species is an actual entity, present in Nature as a real individual thing, and not merely a unit of classification. In ordinary biological usage, the word connotes a sum-total of similar inter-breeding individuals on the Earth. But in reality it is more than that. It is a particular kind of *germ-plasm*—or type of protoplasm—sprawling at large over the Earth's surface, and budding forth innumerable similar "individuals" by a process of serial homology. It is on the germ-plasm, not on the individuals, that we must concentrate attention. Just as protoplasm is one kind of substance among many others on the Earth, so there are many kinds of protoplasm. Each kind appears on its biological side as a species—the countless discrete particles in which it exists being kept in periodic communication by a physical process which again on its biological side appears as sexual reproduction.

To explain how this is so, we must turn to the germ-plasm theory of Weismann. Every individual organism begins its life as a single cell or ovum, a cell being a microscopic speck of protoplasm. In the elementary forms of life it remains a single cell without further development, but in all higher forms it multiplies rapidly to form a colony or nation of cells cleaving together to form what we call the individual. The mode of multiplication is always the same as regards its more obvious features: the cell divides into two cells by a stricture appearing round its circumference. These two daughter-cells quickly grow to the size of their parent-cell, and each then divides again, so that before long large numbers of cells are clustered together. Moreover, as they multiply they become differentiated from each other. Some acquire the characters of muscle-cells, others of nerve-cells, and so on. The higher the organism in the evolutionary scale, the more complete is this differentiation between its component parts. But however high it may be, there always remain some cells which are not differentiated along similar lines to the rest, but retain the primitive protoplasmic characters of the original ovum. From these undifferentiated cells new individuals can blossom forth; they are the germ-cells, and are called by Weismann the germ-plasm, while the body-cells which have become differentiated are called the soma-plasm, and have largely lost the power to produce other cells, except such as are differentiated like themselves.

All multicellular animals and plants consist, therefore, biologically of two main parts—germ-plasm and soma-plasm. Of these the soma-plasm, by far the bulkier portion, is perishable, and after a longer or shorter period undergoes the disintegration of death. The germ-plasm, on the contrary, is not liable to death in the same way. It is relatively immortal. Each generation springs from the germ-plasm of its parents, so that a thread of actual physical continuity connects each generation from the very beginning of evolution down to the present time. The germ-plasm of any individual is the very same germ-plasm as that of his ancestors thousands or millions of generations back. It has been incessantly dividing in two all the time, and the vast mass of its products have either developed into somata or been cast away and lost. But the germ-cell, from which every individual takes his origin, is a real physical portion of that germ-plasm which made up the bodies of his protozoan ancestors, perhaps many hundred million years ago, and which has survived through an infinity of generations, and undergone immense modifications ever since. Thus the life of a species is the life of its germ-plasm, and the species only becomes extinct when the germ-plasm of it dies. The existence of a species is far more than a mere symbol in the terminology of classification. It represents an actually living germ-plasm, one type of protoplasm, or, in other words, a substance of definite chemical properties existing on the surface of the Earth. So long as that substance continues to exist, the species which it represents continues to survive.

A species, therefore, is a more real unit of classification than is a genus or an order, which represent no objects existing upon the Earth, but merely indicate a resemblance between objects. If we wish to obtain an idea as to the fundamental facts of life, we must consider it from the point of view, not of individuals, but of species. For an individual is simply an outgrowth upon a fragment of germ-plasm. It is a highly perishable excrescence, which protects and subserves the continuance of the germ-plasm within it—the germ-plasm being the main fact of the species itself. Unfortunately *we* are individuals, and our first outlook is naturally from the point of view of individuals. But this anthropocentric outlook has to be altered, if facts are to be seen in their correct perspective.

We start, then, from the basis that, in addition to the very large variety of inorganic substances found upon the earth, there are an immense number of the so-called organic substances, which are carbon compounds of high molecular complexity. Carbon enters into so immensely wide a range of combinations, that the study of its compounds is one of the most important fields of chemical science. And among the most complex of these compounds are the innumerable types of protoplasm. To the chemist they differ from other substances only by virtue of the large number of atoms contained in their molecules, so that they are the most complex substances with which he has to deal. The biologist calls them species, whether of animal or plant. Their chemical properties are complex in proportion to their structure. Those same properties are recognized by the biologist in the functions of animals and plants; in their modes of growth and reproduction; in their instincts, and even in their intelligence, their emotions, and their will.

We have, then, first to inquire into some of the more singular properties of protoplasm. We note that it exists in the form of cells, which increase in size by internal absorption. Inorganic substances are similarly found in discrete masses of specific structure, known as crystals; but they increase in size by external accretion. The tendency to grow out into a specific form is specially characteristic of protoplasm. The germ-plasm of any species buds out innumerable homologous excrescences upon itself, all very similar to one another, like the leaves on a tree. These excrescences are the individuals who, taken collectively, make up the species as it appears to man. But the germ-plasm or protoplasmic substance slowly alters in constitution: it undergoes *variation.* What this variation consists in, is not known, but its results are visible in the different types of excrescence which it grows upon itself. This change of character may in the course of ages attain a very far-reaching effect. The germ-plasm of man, for instance, countless ages ago did not produce what we should now recognize as a man, but a creature more like an ape. Still earlier, it grew upon itself a fish-like animal, which swam in the water; nor has it yet altogether lost the traces of this property, for the human fœtus at a certain stage of development still has gill-slits, which occasionally persist even up to birth. Far earlier still, the human germ-plasm grew upon it individuals even more unlike what it grows now, until right back near the origin of life it had no power to grow an excrescence at all, but lived as a single cell in a free and independent life. Even of these early stages some traces still remain. The proportion of sodium, potassium, and calcium ions in sea-water and in blood-serum are almost identical; but the total concentration is higher in sea-water, for the sea has become more salt since it circulated in the body of the earliest ancestors of man. The germ-plasm thus slowly changes its constitution in course of vast ages. It is physically the same germ-plasm, though its chemical and physical properties have undergone alteration. The biological counterpart of this phenomenon is evolution. It is to be noted, however, that the slow modification in the structure of protoplasm is paralleled by modifications in the structure of inorganic substances. We have already seen how the more complex atoms are slowly built up or disintegrated under different conditions of the environment. Similarly, complex molecules exist in one state of the Earth's surface, but have changed their constitution in another state. The properties of protoplasm differ from the properties of an inorganic substance only as its chemical and physical constitution is different from theirs.

A more singular feature of protoplasm, and one which removes it still further from other kinds of substances on the Earth, is that which on its biological side appears as sexual reproduction. This is a contrivance by which the germ-plasm of a species, normally broken up into a large number of separate portions, preserves a continuity, each separate portion being merged at intervals in another portion, so that the entire germ-plasm retains a physical unity, in the sense that no single portion can live in isolation from the rest for more than a certain period of time. The essential fact about sexual reproduction is the fusion of two germ-cells together, these cells nearly always emanating from different individuals. A human analogy will indicate how effective this process is in achieving the unification of species by merging each isolated fragment in the common stock at definite intervals.

Every man has two parents, four grand-parents, eight great-grand-parents, and so on in geometrical series, so long as no intermarriages have taken place. On this condition, the number of his ancestors in the tenth generation back will be 1024. On going back as far as the twenty-first generation, and still supposing that no intermarriages have occurred, the number of his ancestors in that generation alone will exceed two millions. If we reckon a generation at thirty years, we conclude that six hundred years ago the number of persons then existing who have borne a part in the production of our own individual body exceeded two millions. But less than six hundred years ago, when the Black Death had ravaged the country from end to end, the whole population of England probably did not exceed two millions. On the supposition, therefore, that there have been no intermarriages and no admixture of foreign blood, we must each represent in our own body the germ-plasm and characteristics of the entire population of England less than six centuries ago! Six centuries is a long period by the standards of individual life, but it is as nothing in the life of the germ-plasm—in the history of the species. We see that in the course of these centuries there has taken place a complete pooling of the germ-plasm of the population, so that every living individual is related to every other individual by physical continuity of germ-plasm at no very distant period of time.

The case is the same if, instead of tracing the generations backwards into the past, we trace them forwards into the future. If the numbers of the population were to remain stationary, and other conditions are as before, a man may expect that his living progeny in six hundred years' time will exceed two millions. From these two examples, we see the everlasting process of diffusion and re-integration of the germ-plasm. In the first example, the scattered germ-plasms of two million persons have united in the production of one; in the second example, the germ-plasm of one individual has diffused into the inheritance of two millions. It is mere fancy for any one to-day to point out a definite individual several centuries back as "his ancestor." The people of to-day are in a body the children of the people of ancient times. The heredity has been completely diffused and intermingled; so that, going back some centuries, it would be much harder to find a man who was not our ancestor than one who was, excluding persons, of course, whose descendants have altogether died out.

We thus reach a new conception of species. The germ-plasm, or physical sub-stratum of the species, exists, like other substances upon the Earth, in discrete fragments scattered at large. But, unlike those other substances, the discontinuity is not absolute. Each separate fragment is merged from time to time in the common stock. The germ-plasm of any species has a unity and individuality of its own. By a rough analogy it may be compared to a network, each knot representing a soma or individual budded forth from it. Two separate strands unite to form the knot, and from it spring on the average two separate strands again. The analogy is exceedingly imperfect, for a network is an existence in space, and we are dealing rather with a phenomenon in time. It serves, however, to illustrate the fact that direct physical continuity exists in a sense, or has existed, between every individual member of a species. By going back far enough, we can travel from any one knot to any other knot by a complete succession of strands: between any two individuals of a species there exists a protoplasmic linkage which, though it may be remote, is never broken by a discontinuity. A striking difference, therefore, between protoplasm and simpler substances, is that the various types of protoplasm found on the earth, and representing the various species, each constitute an organic unity embracing all the scattered particles that exist.

The reason, or rather the effect, of this arrangement is obvious. The constitution of protoplasm is subject to variation. By incessant pooling in the common stock, individual variations are merged in the general germ-plasm. They there contribute their quota of modification, tending towards modification of the species. But no variation is likely to remain permanent, unless a large number of individuals are affected by it or unless it has a remarkable stability and dominance; the resultant effect may then be sufficiently great to influence the character of the whole germ-plasm, whereas a minor variation brought in by only one or two individuals is likely to be swamped out among the rest. In short, the effect is to limit the variability of protoplasm. By sexual reproduction the whole species preserves a common constitution; it can only vary *en masse;* isolated departures from the normal soon die out. Were it not for this arrangement, animals and plants could no longer be classified into separate groups as they are now. Every animal or plant would have a separate and independent structure of its own. The individual, not the species, would be the basis of life; and instead of finding, as we do, classes, orders, genera, and species marked off tolerably clearly into groups, we should find the whole field of biological vision dotted indiscriminately with living beings having every imaginable variety of structure and of function, and not susceptible of any natural classification.

As to the causes of variation, nothing is known. We merely perceive that protoplasm is of somewhat indefinite constitution, and easily liable to modification. The actual causes of that modification are no more known than the causes of modification of atomic structure noted in the last chapter. Certain phases of stellar evolution seem to favour the development of certain types of matter, which disappear again when that phase is past. One phase favours the development of protoplasm, *i.e.* the development of life; and protoplasm, being more complex, is more plastic than other substances; its elaborate chemical and physical constitution is very responsive to external change and is less stable than that of simpler inorganic substances.

Given the fact of variation, the origin of species becomes more intelligible. It may be that a few individuals bring into the common stock of germ-plasm a new variation of so strong and stable a character that it cannot be swamped out, but gradually imposes itself upon the whole species. Or it may be that, by geographical or other causes, one part of a species is cut off from another part. Their germ-plasm is cut in twain, and each section proceeds to develop on its own lines. We thus have the small differences between the English pied wagtail and the Continental white wagtail; between the English coal-titmouse and the Irish coal-titmouse, and so on. The two divisions of the severed germ-plasm are starting on independent lines of evolution, owing to a cessation of interbreeding between them.

Protoplasm exists in the form of cells, or small globules of jelly-like consistency. These unit-cells increase in size by absorption of nutritive matter with which they come in contact. As soon as they have attained certain dimensions, however, they cease to grow, become constricted round the middle, and finally divide into two. The daughter-cells so formed go their own way, grow, and then divide like their parents, and so on *ad infinitum.* Primitive forms of life are thus limited to single cells. No soma-plasm yet exists, and sexual reproduction consists in the fusion of two entire organisms. As evolution progresses, a change takes place. The cell continues to divide in two as before, but the daughter-cells are incompletely separated. Division and re-division continue until a whole cluster of cells is formed, loosely held together in a single whole. At the same time that this new feature makes its appearance, the cells themselves cease to be all alike, but become differentiated both in structure and in function. Some become modified for drawing in particles of food that are floating by, others become modified for digesting it; some function as rudimentary muscles, others as nerves, and so on. The great majority undergo some kind of modification. Taken together they form the soma or body of the individual. A few, however, retain their primitive characters; these constitute the germ-plasm.

The single cell of the original organism carries on by itself *all* the functions necessary to existence: nutrition, growth, reproduction, digestion, excretion, etc. It possesses in extremely rudimentary form the properties of muscle, nerve, senses, circulation, etc. When, however, owing to incomplete separation, a colony is formed, the somatic cells which become specialized for definite purposes lose their original capacity for fulfilling other purposes. Their greatly increased capacity for some one function involves a loss of capacity for all other functions. Development implies a great gain of one property, with a corresponding loss of all others. Among the properties which are lost are those of producing any cells unlike themselves. A specialized cell usually reproduces only other specialized cells like itself; it ceases, with certain exceptions, to represent the whole properties of the germ-plasm. A mutual interdependence throughout the colony is set up, and natural death makes its first appearance; but both then and throughout evolution, natural death is an attribute only of the specialized somatic cells. The germ-cells may, indeed, die, but they have no inevitable tendency to death, for their life is the life of the species. With the further course of evolution, specialization and interdependence become more and more absolute, until we reach the higher groups of vertebrates, in which every part of the body is marvellously adapted to some special requirement of the animal, whose continued existence is dependent upon a close inter-relation of innumerable different specialized organs and tissues.

Now, from our narrow human point of view, one of the most significant facts about an animal or plant is what we call the purposiveness which seems to control its entire organization. It seems to be an enormously complex piece of mechanism designed for a particular end, namely, that of the preservation of the individual; and this end again appears to be subservient to another and a greater end, the preservation of the species. Nearly every part of the organism is adapted for furthering the life of the whole; not quite every part, indeed, for there are always some structures and some functions which neither are, nor ever have been, of the slightest utility, but are pure chance products and accidents of evolution. Taken altogether, however, an organism is a highly teleological piece of apparatus. In almost every part of it, adaptation to a definite end is obvious, and the sum-total of adaptations to a single end is so striking as almost to justify the term miraculous. Little wonder, then, that until recent times it was supposed to be actually the manifestation of a miracle. It was imagined that every individual had been specially created by a being of infinite power and intelligence. Always among uncultivated peoples unexplained phenomena are referred to a deity, who survives in the imagination until such time as the phenomena can be explained by natural causes. The pertinacity with which men clung to this conviction was a measure of their inability to conceive any alternative. But the mere inability to conceive an alternative does not constitute any proof of a theory; in so intricate a subject as this, it does not even constitute the least probability in favour of that theory. We may very likely be compelled to say that we do not know how these things happened. Nothing is more probable than this; for the more we study, the more we find how little we really do know; and very likely the highest flight of human knowledge will be attained in the Socratic doctrine that we know nothing. But this confession of our own ignorance is a product only of a deeper learning. Among primitive peoples it is unknown. Their range of inquiry and interest is, indeed, small; but all the gaps in it are filled by deities. They ask few questions, but those which they ask they can always answer; for where no natural cause can be observed they confidently assign a supernatural cause, and the matter is finished with. They do not know the meaning of ignorance.

Among civilized men, the range of inquiry is far wider than among savages. But here, too, men are largely unconscious of their own ignorance. They fill the gaps in their knowledge with deities or with a single deity, and to nearly all questions of philosophic import they are ready with an answer. If they know of a natural cause for any phenomenon, they will adopt that for preference; but if they cannot think of any natural cause, they refer the matter without further ado to a deity, as the next best solution of the difficulty. The theological modes of thought are based on the assumption that man must know everything; the scientific modes of thought are based on the assumption that he knows nothing. Here and there a problem *can* be answered, but that is an exception to the rule. As our range of inquiry widens out, the number of insoluble problems so increases that it becomes an exception of the rarest character. The more we learn, the more are we oppressed by the portentous magnitude of our own ignorance. Those who like to fill the gaps in their knowledge with a deity may do so; but they must be prepared for the chance that those gaps may be filled in time by explanations of a natural and not a supernatural character, so that their deity is driven homeless to some other sphere of activity. This perpetual ousting of divinities from spheres supposed to be their own is one of the most interesting lessons of all history, and is largely responsible for the discredit into which theological opinions have now fallen.

At all events, the doctrine of special creation of species was upset last century by Darwin's theory of Natural Selection. This theory is based upon the three pillars of heredity, variation, and the struggle for existence. Darwin assumed that a species tends to vary equally in any direction. Some variations, however, were favourable to the life of the individual, while others were unfavourable or indifferent. He assumed, furthermore, a severe "struggle for existence" within every species, as the result of which a large proportion of each generation dies a premature death. In this competition for existence, individuals who happen to have variations of a favourable character will have an advantage over the others, and will be more likely on the average to reach the age of reproduction. The succeeding generations will, therefore, tend more and more to be recruited from those who possess variations of a life-conserving utility. By heredity, these variations will be handed down, and after a time will become a general characteristic of the whole species. This is the theory of Natural Selection, or, in Spencerian language, the survival of the fittest.

It obviously depends largely on the rigour of the struggle for existence. An example may therefore be taken, to show how extraordinarily keen the process is. The common housefly is said to lay eggs in batches of 120 to 150 at a time, and may deposit five or six batches during its life. In very hot weather a generation extends to about three weeks; that is to say, a newly-laid egg develops into a fly, which in its turn is laying eggs within a period of three weeks. Now if we suppose that every egg laid develops into a perfect fly, that half the total numbers of flies are females, that every female fly lays the normal number of eggs, and that there are six generations of flies in a summer, a simple calculation shows that at the end of the summer the progeny of a single pair of houseflies reaches such an enormous figure that if they were all to be pressed together into a solid mass they would occupy a space of something like a quarter of a million cubic feet, assuming 200,000 flies to the cubic foot. But there is no reason to think that the number of houseflies is on the increase. It hence follows that out of these myriads of potential insects, there will, on the average, be only two individuals who survive to the beginning of the next breeding season. All the rest that are born die an "unnatural" death. Darwin's theory supposes that fortunate variations of a life-conserving character will be a factor in the determination as to which two individuals out of that whole immense multitude shall be the survivors. It is, however, not very easy to acquire complete conviction upon this point. The struggle for existence is so intense that *nearly* every potential individual is overcome by it. The individual insect is no match for its environment; the odds against it are too overwhelming. Can it be supposed that a *small* variation (for Darwin assumed that variations were small) would make a life-and-death difference in this desperate and one-sided struggle? The process would be easier to imagine if we assumed, with later biologists, that heritable variations of a larger type, otherwise called mutations, were the material upon which Natural Selection worked. Even so, the practical working of the process is none too easy to imagine. Let us pass on, therefore, to a further illustration.

In the minute water animals called copepods, the males have their anterior antennae modified into long, whip-like structures which they use as a lasso to throw over the heads of the females, and so to catch them as they take flight. The advantage of this structure for securing survival is obvious. Those males which were most adept in catching females would give rise to a large progeny, inheriting the peculiarity of their parent, while the males who had no contrivance of this nature would have but few offspring, and would soon be swamped out. In this case, it is easier to understand how a slight improvement in the antennae, which facilitated the task of holding the female, would give the male an advantage in reproducing over males which had no such favourable variation. The small variations might thus become fixed and gradually increased by heredity.

The predominant opinion at the present time is that Natural Selection offers no adequate account of the process of organic evolution. The complexity of life is so astonishing and inconceivable, the adjustments and interrelations both of structure and function are so infinitely delicate and elaborate, that the simplicity and obviousness of Natural Selection appear altogether incongruous by the side of the facts which it is alleged to account for. And there are many other difficulties. Natural Selection postulates that every organic structure has some life-conserving value to the organism. But the number of differentiated parts of a mammal, for instance, is so immense, that if we suppose each of them separately to be developed by Natural Selection, the time required for evolution would be far greater than is geologically possible. Moreover, every structure in an organism is not of life-conserving value. Take, for instance, two closely resembling birds, the blackcap and the garden-warbler, both belonging to the same genus *Sylvia*. In every respect of structure and habit, they are exceedingly alike; even their song is hard to discriminate. But one has a black crown on his head, and the other has not. Now, if Natural Selection is all-embracing, we must suppose that this black crown has a survival value; and to such an extent that all individuals without it have become extinct. That is the extreme doctrine of Natural Selection. But if a black crown is so vital a necessity to the blackcap, how is it that the garden-warbler continues to flourish, though his head is of the same dull colour as the rest of his body? Must we suppose that there is some other obscure adaptation, which relieves him from any necessity for a black head? It may be so; but there is not the least ground for thinking it, except for the one purpose of maintaining the Darwinian doctrine. Moreover, why does the female blackcap have a reddish instead of a black crown? They each take a turn at incubation, so that it appears to be of little importance to the individual what colour the crown of his head is. In short, the example does not, indeed, disprove Natural Selection, but it involves some stretching of facts beyond what we can observe in them. And so in multitudinous other instances, facts have to be stretched if the theory is to be maintained, until at last the theory itself falls into very grave doubt. Finally, Jacques Loeb has indicated sundry properties of animals which can have no utility to the organism whatsoever.

To account for these discrepancies, various modifications have been suggested. A structure may now have no value to the individual; it may be a mere survival of a structure which once had a value, and has now lost its purpose, and is on the way to extinction—as, for instance, the rudimentary legs of whales and of snakes, the eyes of cave-dwelling crustaceans, and so on. Or a structure may neither at the present nor at any past time have had any value, but it may be correlated in some necessary manner with another structure which has, or has had, a value. But we are here already departing from the all-sufficiency of Natural Selection. And as we do not see any reason for supposing such correlation, except out of regard for maintaining the theory, it remains a pure hypothesis. It may quite well be so, and is quite in accordance with what might be expected; but there is no evidence of detailed cases, and so we cannot say whether it *is* so or not. The more closely we study Natural Selection, the more numerous are the untested hypotheses which we have to invoke, until at last this clinging burden of parasitic hypotheses threatens to submerge the central doctrine which they were intended to buttress.

In short, the great and enduring value of the doctrine of Natural Selection has been somewhat clouded by the exaggeration of the claims made on its behalf. In the middle of last century, it was a popular belief that all parts of an organism had some utility. Darwin accepted this assumption without inquiry, and on that basis erected his theory. The theory departed in many respects from popular opinion; in those respects it was fiercely assailed, and, as we all know, it made good. For it was not in error where it differed from popular opinion; it was in error only where it agreed with popular opinion, and thus escaped criticism. Popular opinion was wrong from top to bottom; Natural Selection was a first approximation to the truth, but it was unfortunately hailed as the whole truth by its disciples, and attacked on mythological grounds by its adversaries, a mode of attack which ultimately tended to strengthen rather than weaken it.

Natural Selection, then, is a plausible, even if it is not the sole factor in the development of utilitarian structures. The real value of the theory is not in furnishing a cause of evolution, but in showing why animals and plants are so largely purposive in their structure. Natural Selection shows that they could not be otherwise than purposive. It is clear that, on the likely assumption that variation is completely haphazard, all variations that are definitely unfavourable will tend to die out, for the simple reason that the organism possessing them cannot exist. Neutral variations will tend in a lesser degree to disappear. For the possession of a useless organ will necessarily constitute a handicap in the struggle for existence; it draws sustenance, has to be carried about, is a burden on the organism, to which it gives no counterbalancing advantage. Often, indeed, like the crown of the blackcap, it entails no extra demand upon the animal; and in all cases of that kind, Natural Selection is inoperative. Thus, Natural Selection shows us why animals and plants on the whole are organized on a purposive basis. If they were not, they could never have evolved. Natural Selection is not a cause of evolution, but a condition of evolution. It limits evolution in the main to what we call purposive effects. It rules out all other possible spheres of development, leaving only this one, within which all organisms have to evolve, unless they die out. It has an added philosophic interest, in showing how a teleological organization may be achieved by blind physical laws. Animals and plants are teleologically organized, because they cannot be anything else.

The real causes of evolution are no more known than the causes of variation. Various factors have been at one time or other suggested; in particular it used to be believed that somatic modifications could be inherited, and that the environment, acting direct upon the soma, could modify the germ-plasm. But this belief has now been generally abandoned, and the position is that very little is known as to the causes of evolution. We have for the present to be content with the fact.

The question has been widely discussed how life originally started upon the Earth. One of the most popular theories is that living germs were brought to the Earth's surface by meteorites, which are constantly falling upon our globe. Many difficulties confront this theory; and Arrhenius suggested a modification, according to which the germs were driven through space by the radiation pressure of light, and not on any material body. Their infinitesimal size would justify the belief that they may be conveyed along on the phantom wings of a wave of light.

No explanation of this character is satisfactory, however. It is, of course, purely a guess, but then speculations on the origin of life can scarcely be more. Even as a guess, it is far from satisfying; for it offers no solution of the origin of life, but only of the way in which life got on to the Earth. It merely removes the difficulty one step out of sight; it transfers the problem from the Earth to another and unknown part of the Universe. Let us look at the matter broadly.

The integrated bodies which are suspended at vast intervals throughout our Universe—bodies which we call planets and suns—are believed to have been derived in the course of unimaginable epochs of time from nebulæ. As to how the evolution proceeds, the physical causes at work, there has been wide speculation; but we are now concerned only with the end-product, the appearance of bodies at enormously high temperatures, which gradually fall to the cold of surrounding space. It is not known what temperature exists in the hottest stars; 30,000° C. (54,000° F.) has been suggested, on which basis the Sun now would be over 8000° C. (say, 15,000° F.) But this is a mere guess. It indicates, however, the enormous difference of physical conditions prevailing at the outset of evolution, by comparison with conditions now prevalent on the Earth. In these very hot stars, there is every reason to believe that matter exists in a very different form from that in which we know it. The spectroscope discloses in them very few of the elements which we know on the Earth, and those few for the most part of the simpler and lighter kinds. Even these elements appear often to exist in embryonic forms only, to which have been given the names proto-hydrogen, proto-iron, etc. We cannot doubt that they are ultimately composed of electrons; but we have no reason to think that the electrons are combined together to form just the atoms we now know, and no others. The original primeval atoms of an early star are something more rudimentary than the simplest of all *our* atoms—that of hydrogen. Nor are we obliged to assume that the matter of which they were composed must exist in one of the three states—solid, liquid, or gas. Just as the atoms differ from our atoms, so the matter which they form may exist in some fourth state, of which we have no experience.

As evolution advances, and the stars get cooler, a greater number and variety of atoms appear on them. Iron and the metals are formed, and the number of substances gradually increases, until, at temperatures corresponding to our own, we find a wealth and complexity of different substances resembling those which we know. In short, a spectroscopic study of the stars indicates that the most elementary atoms are formed first; then the heavier ones; and lastly the heaviest of all, uranium, thorium, radium, which, as conditions continue changing, begin to disintegrate again as they are now doing upon the Earth. In short, a true natural selection occurs in the atomic, as in the organic world. Atoms of any kind may be formed, but only certain kinds are suited to their environment, and they alone persist. At one period the environment favours the existence of certain new atoms; but at a later period does not favour their existence, so that they tend to extinction. Uranium on the Earth is travelling the same path that Dinosaurs have already travelled, and very broadly for the same reasons of philosophical physics. If we were made of uranium, instead of protoplasm, we should apply the term "purposive" not to the reactions of organic matter, but to the chemical properties of uranium.

After a certain period of evolution, a stage is reached like that of our Sun, a monstrous maelstrom of wildly agitated matter and energy, with a heat that burns and a light that dazzles a hundred million miles away—while from its surface there spring forth from time to time great jets of gas, which in ten seconds may reach the height of 300,000 miles. Plainly no life is possible there.

Let us transfer our attention now to the Earth. As cooling proceeds, an external crust begins to appear, a differentiation between the inside and the outside. At first it is thin, rocking upon the oceans of gas beneath, and is often broken through. Dense clouds of vapour obscure the Sun; titanic hurricanes shake the very surface of the Earth, while deluges of hot and acid rain gradually pile up the waters of the ocean. Later still, the crust becomes more stable. During the molten stage the heavier substances, like metals, had largely sunk within; the lighter—the quartz and the feldspar—now freeze upon the surface, leaving a bald expanse of granite over which the waters continue to accumulate.

Now is the time when we must look for the origin of life. The atmosphere has discharged the greater part of its water-vapour; the clouds at length break, and the Sun shines for the first time upon the newly-formed crust of the Earth. The temperature of that crust has fallen well below the boiling-point of water. The conditions have arisen in which yet a new substance can be synthetized—the substance which we call protoplasm. Why need we look to distant corners of the Universe for the origin of life? We know that the conditions, wherever it originated, must have been something like those existing on the Earth. What need then is there of extraneous hypotheses and an exotic origin? We know that the Earth was suitable for life; we have no observational evidence that any other part of the Universe was suitable. We have to assume, firstly, that some other part of the Universe was suitable, and secondly, that the germs could be conveyed across space. Why then drag in these two hypotheses, with their attendant difficulties, when they add not a whit to our comprehension of the matter? For it is in every way simpler and requires far fewer assumptions to suppose, that the life of the Earth originated *on* the Earth. This assumption is just as easy to conceive as that it originated elsewhere, and is not beset by the further almost insuperable difficulties as to how it traversed space.

The real reason why life is imagined to have been introduced on to the Earth is to get over the difficulty of its origin by assuming that it always has existed somewhere since the beginning of time. Now life is merely a name for the sum-total of the physico-chemical properties of protoplasm. Why are we to suppose that protoplasm—the most unstable and perishable of substances—has existed through all eternity? Other far simpler substances are integrated and disintegrated as their environment changes. Has protoplasm alone survived all the incidents of cosmic evolution? A fortiori the simpler inorganic substances have done the same, then; and the Universe a myriad æons ago was not so different from the Universe of to-day. If there were a vital principle, an essence of life, then, indeed, it might survive for ever, for anything might be predicated of it. But if life is a mere manifestation of protoplasm, the doctrine of its permanency loses all verisimilitude.

It is undoubtedly true that no reliable evidence exists to indicate that at the present time life is being evolved *de novo* from inorganic substances. In fact it is very nearly certain that no origination of life on the Earth is now taking place, at least in a form that can be detected under the microscope. This truth, however, has no bearing on the question whether life originated under the altogether different conditions of the Earth's surface at the period to which we are alluding. In any case, since there is no fragment of evidence upon the matter, there is no question at all that the simplest and most probable hypothesis we can form is that the formation of organic substances follows the same principle as the formation of inorganic substances. In the earliest phase of stellar evolution, the substances in existence are few and elementary; at later stages they become gradually more numerous and more complex; until at last synthesis of the carbon compounds gives rise to the proteins, more varied and more complex than any substances previously formed. If it were not for the mythological bias, no one would ever have suggested that the highly complex compounds of carbon were formed in any different way from the compounds of any other element.

Whenever it was that the Earth's surface was first able to support life, it seems reasonable to believe that the rudimentary proto-organisms were considerably simpler than the simplest we can now see. The very elementary *amœba*, one of the simplest of all animals, has already a definite structure and stable physiology. It has a nucleus, a contractile vacnole, its exterior and interior are differentiated; the functions of nutrition and excretion are elaborate and definitely specific. The *amœba* has already travelled a long way from its ancestral inorganic parentage: it must be the product of a long evolution, the earlier phases of which are now either extinct or unrecognizable through the microscope. The origin of life, we may reasonably suppose, was as primitive specks of protoplasm, of exceeding minuteness, and showing scarcely a trace of any structural differentiation; and probably ages must have elapsed before any creature of so specialized a character or so large a size as *amœba* could be developed. Indeed, if life is still originating *de novo* on the Earth, it would be too much to expect that our microscopes could discover it.

Once the germs of life were in existence, the great differentiation soon began between animal and plant life. Whether these are the only possible forms of life, or whether on other planets or in other parts of the Universe quite different forms of life may have been evolved, we cannot tell. We may be certain, indeed, that their species are intensely different from ours. At all events, we know that on this particular planet two main forms of life appeared, which we call animal and plant. The records of their evolution are preserved to us in the form of fossils. These records begin somewhat late: not until the habit of secreting lime resulted in hard skeletons which could endure through geologic epochs. By that time, the main invertebrate groups had already come into existence; the story of their evolution is thus lost in the hopeless mystery of a past that is enormously remote. The vertebrates, on the other hand, were just beginning their career. The theory now most generally accepted is that vertebrates took their origin, not in the sea, but in the running waters of the land. In any case, they breathed by means of gills, and the change from a water to a land life must have been a formidable crisis of their development. It was perhaps due to a period of great aridity, which gave a powerful impetus to the evolution of such creatures as could live apart from water. The earliest known fishes with lungs belong to the period of the Lower Devonian. How precisely they emerged from the water to live upon the land is a subject only of speculation. But the fact remains that they lost their gills, grew lungs, took to breathing air, and to walking upon the dry land.

Up to this period no trace of any land vertebrates have been found. But at length, on reaching the rocks of the Upper Devonian, the footprint of a land vertebrate has been discovered. This, the earliest known terrestrial footprint, indicates an animal with at least four toes, the first and the second being by far the largest. These amphibians soon began to abound when a wetter age succeeded. Swamps, jungles, and forests were then their habitat—those same forests which at distant future ages were destined to supply us with coal. They had a protective covering of armour, looking like immense but stumpy newts. They had not yet lost all connection with their ancient home in the water, for they still went there to breed and their young were still born with gills.

A new age of drought came on, however; the rivers began to dry up, and the amphibians found it increasingly difficult to obtain sufficient water for their breeding purposes. Under these circumstances, they gradually abandoned the water and took altogether to the land; and thus perhaps were reptiles formed. The reptiles divided into two main branches, one of which led to Dinosaurs and to birds; the other to mammals, and ultimately to Man. Owing possibly to a severe glacial epoch in early Permian time, both branches[1] acquired warm blood, which protected them from the extreme rigours of the age. But at first the mammals showed no signs of their future greatness; they were small and humble creatures, which fled precipitately on the approach of the carnivorous reptiles. Throughout the vast era of Mesozoic time, Dinosaurs (mostly not carnivorous) were monarchs of the Earth. Of immense size and high specialization, they entirely dominated the land surface of the Earth; and we can well imagine our small mammalian ancestors scuttling away at their approach into the nearest thicket of ferns or cycads. Had some denizen of another planet visited our Earth during this period, and had he been addicted to teleological explanations, it would have been obvious to him that the great Dinosaurs, walking on their two hind-legs, were the lords of creation. He would have noticed that it was an age of reptiles, for whose sustenance an all-wise Creator had supplied a number of small hairy creatures, running timidly on all-fours, but not too difficult to catch. He would scarcely credit the hypothesis of "civilized" man, that the Earth, the reptiles and all other forms of life, nay, even the sun, moon and stars, were *really* made in the interests, and for the exclusive purposes of, certain among those furry quadrupeds who happen to be the ancestors of Man.

At all events, after many million years the Mesozoic period passed away; the reptiles declined from their former greatness, and left the ground comparatively free for the rise of the age of mammals. How the Reptile Cynodonts developed into mammals is not known; but after the evolution had taken place, there occurred the long stagnation already mentioned, under the heel of the reptiles. The first age of "archaic" mammals was swept away by an invasion of more modernized

[1] Possibly not the Dinosaurs.

mammals during the period of the Eocene. These, and further waves of invasion, appear to have emanated from Northern Asia, or at least from circumpolar regions. Thence they spread South, and after one or two waves which brought monkeys on their crest, one came at last which brought men. Their evolution from an arboreal ape, like the gibbon, may perhaps have taken place in Central Asia. In any case, it seems to be geologically a very recent event, dating back to the inception of the last Glacial epoch, which may, perhaps, have occurred something like 100,000 years ago. It is futile to give figures as to the age of the Earth or the different geologic periods, for no approach to real knowledge has yet been attained. Still, guesses may be useful in order to get a general idea of the proportion of the various events, so long as we avoid regarding the hypothetical figures as any real index to the facts. On this basis, we might set the age of the Earth geologically at 1000 million years. In that case, the Age of Reptiles might have begun about 200 million years ago, and lasted over 100 million years. Supposing that the dominance of mammals began fifty million years ago, the result emerges that however inaccurate our figures may be, one thing is certain, the evolution of man from the apes is an occurrence of extraordinary recency.

At length the records of geology give place to those of archæology. Eoliths are found—curiously shaped pieces of flint which may or may not be of human workmanship. Then comes the Palæolithic or Early Stone Age, with flint implements, roughly shaped, but of undeniable human orgin. At this time the face of Europe was still very different from what it is at present. Great Britain was united to the continent along its eastern and southern boundaries. Where the North Sea now is, was a wide valley, down which flowed the waters of the Rhine, swelled by its tributary, the Thames, and reaching the sea not far from the Faroe Islands. Where the English Channel now is, was similarly the valley through which the Seine reached its destination in the Atlantic Ocean.

The Mediterranean was traversed by an isthmus connecting Africa through Sicily with Europe. Possibly, Europe was still connected with Greenland through Iceland and the Faroes. The Great Ice Age had completed its first episode; the ice which had covered the greater part of Europe had receded for a time and left a fine warm climate. In England, elephants and rhinoceroses wandered at large. Hippopotamuses disported themselves in the waters of the Thames. Bison, wild horses, deer, and the sabre-toothed tiger were all common.

Gradually the ice began to advance again. The hippopotamus and other denizens of a warm country disappeared. The mammoth became abundant; and among other animals were the reindeer, musk-ox, glutton, arctic fox, and lemming. It was perhaps owing to the steady deterioration of the weather that Man first took to living in caves, where he made those wonderful paintings that are still to be found. At one of these caves, at Niaux in the Pyrenees, may still be seen in the sand the imprint of a human foot, left there we know not how many thousand years ago. The dominant race of that age seems not to have been artistic, however. Their skeletons suggest a race of man who had a very large nose and long upper-lip. Over the eyes extended a prominent ridge, and the forehead was receding. The jaws were large and heavy, especially the lower jaw, which was further remarkable for the absence of a chin. The wisdom teeth, instead of being, as among existing men, the smallest of the molars, were the largest.

Some of these ancient men appear to have had brains even larger than those of modern Europeans. And they must indeed have needed them, to protect themselves from the terrible rigours of the Great Ice Age. It is not known when the discovery of fire was made, nor when men began to communicate their ideas by means of language. But, at all events, the artistic races of Palæolithic hunters were swept away not less than 7000 years ago by the Neolithic men, who tilled the land, kept herds, built modern houses, sometimes on piles in the water, like the Glastonbury lake-dwellers. Their implements, though still made either of flint or green-stone, were often polished, and showed a very high standard of workmanship. For the Ice Age had finally passed away; the climate was mild; Europe was a rich, moist pasture-land with abundant peat-bogs and woodlands.

It was perhaps in North Africa that the use of iron was first discovered. Dates are still dubious, but it may have been 6000 years ago. And it was then, or later perhaps, when the big stones of Stonehenge were being set in position, that the Bronze Age replaced the Stone Age. The Ancient Britons were still in the Bronze Age at the time of the Roman Conquest. The Romans themselves had already passed from it to the Iron Age some centuries previously. And so, at length, archæology passes into history. The arts of writing and of numeration are invented. Artistic genius suddenly bursts forth in the wonderful efflorescence of Greek civilization, which died down after a brief life, almost as quickly as it appeared. Philosophy took shape, and advanced to a surprising height, till it was overwhelmed again by a thousand years of barbarism and religion. But the light dawned once more with modern history. Printing was invented. Philosophy, science, and art slowly evolved to their present state. In the case of science, the advance is cumulative. The genius of individuals does not perish, as it does in art: it becomes the property of all men, and each generation starts its labours on a higher platform than its predecessors.

We conclude, then, that Life is a name for certain properties of protoplasm, and that biology is the science which deals with the physico-chemical reactions of that highly complex substance. We find, moreover, that protoplasm, in common with far simpler substances, undergoes an evolution; and the fabulously protean forms which it adopts are the outward and visible sign of a fabulous molecular complexity within. We have dealt with Life, but we have not yet dealt with consciousness, seemingly so different in texture from all other classes of phenomena. The actual relation of mind to matter will be dealt with in later chapters. What we have at present to discuss is where consciousness first appears in the course of cosmic evolution.

The most plausible belief is that it is coeval but not coextensive with life. We note about both of them that they stand in closer relation to *function* than they do to *structure.* A unit of protoplasm, in which all physico-chemical processes are at a complete standstill is no longer alive but dead. Spores and seeds, in which no visible alteration is taking place, are none the less in process of alteration. They may be kept some years without losing their powers of growth or germination. Indeed, it used to be asserted that seeds preserved with Egyptian mummies are still capable of germination, but this is now known to be a myth. However lifeless a living thing may seem, there are always some physiological processes going on while it has life; and if seeds are kept from germination, they lose their vitality and die in quite a few years. Life is signalized by incessant physiological change. It is not structure but function that constitutes life, and the same truth holds of consciousness. They are not *things* but *processes*, or a congeries of processes.

Life is a name for the physico-chemical reactions peculiar to protoplasm, and when those peculiar reactions cease, life is extinct. Doubtless structure in all cases underlies function; and the cessation of the reactions implies molecular alteration in the protoplasm. Now, seeing the general resemblance between the conception of life and the conception of consciousness, are we not to infer an essential similarity in their origin? Can we associate consciousness with the reactions of any specific material substance, as we associate life with the reactions of protoplasm? We most certainly can. Every modern psychologist agrees that consciousness stands in special relation to the functions of the nervous system. What we call consciousness appears on the objective side as the activity of certain portions of the brain. Specific physico-chemical reactions of nerve-tissue are an invariable aspect of all forms of consciousness. I propose, indeed, to show later that these specific reactions actually *are* consciousness, in precisely the same way that the specific reactions of protoplasm actually *are* life. In neither case is there a separate existence or entity; though our own outlook is so intensely central and interested, as to make the fundamental unity somewhat difficult to perceive.

We must leave the formal proof of this doctrine to Chapter VI. For the present we note it only for the purpose of identifying the moment of entry of consciousness into the course of evolution. It appeared when nervous tissue first appeared. And since even the elementary *amœba* possesses throughout its body the rudiments of nervous function, we must suppose that the rudiments of consciousness date right back to the earliest phases of animal life. It would, indeed, be difficult to harbour any alternative hypothesis. Evolution presents an unbroken chain from pre-Protozoan life down to Man. Throughout that period the germ-plasm has retained its individual material continuity. There has never been a new germ-plasm through all those ages of evolution; it is the same old individual germ-plasm changing its chemical constitution. There is no point of evolution at which we can conceive the entry of a totally new thing. The rudiments, the potentiality, of consciousness were present from the start.

The conclusions of the last two chapters may be summed up in a few lines. The final and, as far as we can tell, unchangeable units of existence are the electrons. They are not matter, they are not energy; but from them both matter and energy are born. The electrons combine together in a number of different ways, and we get a corresponding variety of atoms. The atoms combine, and we get molecules. Some of these molecules contain vast numbers of atoms. These complex entities combine again to form the still more inconceivably elaborate substances called proteins. And yet again the protein molecules join together in systems, till we get still another substance, protoplasm, where the incredible degree of chemical elaboration has reached such a state as to have lost all semblance to the simple reactions of the laboratory. The sum-total of these reactions is so far beyond the range of chemical analysis that we can do no more than lump them stupidly together and call them collectively by a new name—Life. Nor have we yet done. Further elaboration of the molecules of protoplasm gives rise to a new and distinctive set of reactions, which again paralyze the intellect of Man; and he can do no more than invent a name for them—he calls them Consciousness.

Are the marvels of Life and Consciousness any greater than those disclosed to us by Astronomy, or those disclosed by Physics? It is hard to say. One thing alone is obvious. In all these three spheres we come at the very first step upon facts so remote from common life as to overwhelm the imagination with the magnitude, with the smallness, with the variety of our Universe. Our faculty of wondering is quickly exhausted in all spheres. We can only feel vaguely that in any of them, no finite imagination would suffice to represent the facts. To appreciate them in their reality, we should have to be gods and far more than gods. We are forced to the conclusion, not merely that *we* can have no understanding of these things, but further, that there can be no understanding of them anywhere.

CHAPTER IV

THE FALLACY OF VITALISM

THE most acute phase of the conflict now raging between spiritualism and materialism is that comprised within the sphere of physiology. During last century the main action was carried on within the confines of zoology and botany. Materialism there became identified with the theory of evolution, and especially of the common origin of Man with the lower animals. The philosophical controversy was for the time narrowed down to a single important question of fact—a question to which an assured answer could be given within the range of a single science. Many of the disputants in the evolution controversy, indeed, did not perceive, though they must certainly have felt, the larger philosophical implications of their discussions. They did not overtly recognize what few now would call in question, namely, that the evolutionists were the historical representatives of the materialistic mode of thought; that evolution *v.* fixity of species was the passing phase of a controversy which has always existed, and which indicates the greatest of all cleavages between the opinions of intellectual men. That the true nature of the dichotomy was more clearly perceived by the spiritualists may be gathered from the unanimity with which they attacked the new theory, and labelled it with the titles of materialism and atheism.

Any such narrowing of this great controversy, so that it falls within the limits of a single science, is an extremely welcome and valuable thing. A clear issue can be at once joined on a question of fact; the question of fact can be decided by a body of scientific investigators, whose interest is confined to this point alone, and is commonly not extended to the larger philosophic implications of their decision. Effectively, therefore, the point at issue is decided exclusively on its own merits by a group of impartial and highly-trained observers, who sum up among themselves the entire knowledge available to humanity on the point at issue, and who are not liable to be much affected by those collateral issues which excite such deep prejudice among the ignorant public. The biologists decided on the truth of an evolution theory, and the controversy then died out. Materialism emerged triumphant from the dispute; spiritualism was correspondingly narrowed and depressed.

Within the last few years the great dispute of philosophy has once again been concentrated on one problem, whose solution lies within the range of a single science. The science to which I refer is physiology, and the problem is that of mechanism *v.* vitalism. I am, of course, very far indeed from suggesting that this problem is new, for it is at least as old as the dispute on evolution. Both problems throw back roots for several centuries, and were half discerned even by ancient philosophy. But their prominence in men's minds has constantly been altering, according to the temporary phases of materialistic progress. Whereas last century the evolution theory rose to the highest point of public interest, and was then settled for all time, so now the discussion of vitalism has acquired an exceptional interest, if not for the general public, at least for physiologists and psychologists; and the universal acceptance of the mechanistic solution cannot long be delayed. When once this is achieved, the ultimate victory of materialism will be immensely accelerated.

For the purposes of this work, the only branch of physiology requiring attention is the physiology of the nervous system, for it is only in this branch that any remnants of vitalism survive. There was a time when all the functions of the body were set down to supernatural agency or direction. Such, for instance, was the case with the production of animal heat up to 1780, when Lavoisier and Laplace showed that it depended upon oxidation. The formation of animal heat was thus proved to be a purely physico-chemical process, of precisely the same character as occurs in inorganic nature. In modern times, however, the truth of mechanism is only questioned in respect of the highest functions of the nervous system—those, namely, which regulate the thinking and conduct of men.

Mechanism is the theory which regards the organism as a highly complex machine, controlled exclusively by physico-chemical laws, without any sort of action or guidance by any force or power foreign to the conceptions of physics and chemistry. Vitalism, on the contrary, asserts that living organisms possess within them some directive power or force of non-material nature, and therefore unknown to science. This force, called the vital force, is supposed to control some or all of the activities of the organism. It removes the living body from the exclusive operation of physical forces, and constitutes it something apart from all other bodies, and inherently different from them by its very nature. On the assumption of vitalism, the living organism is something more than an incident in the universal redistribution of matter and motion; its activities are in part the product of totally new forces, which may be manifestations of a soul, a mind, or other spiritual entity. It is part of the purpose of this book to deny the existence of entities of this character. In the region of physiology, therefore, it is necessary to show that the activities supposed to be due to these entities are in reality due to physico-chemical factors. We have to consider not the alleged entities themselves, but the alleged forces which they exert in the animal organism.

That there is no *creation* or *destruction* of energy within the organism is now an established fact. It is no longer questioned that the quantity of energy escaping from the organism, in the various forms of mechanical work, heat, chemical products, etc., is precisely equal to the quantity of energy absorbed into the organism, whether in the form of chemical energy in the food, or as light, heat, etc.[1] It is equally beyond dispute that the total quantity of matter entering the organism is precisely balanced by the quantity of matter leaving the organism, exclusive of that which may have been used for growth of the organism, or lost by a diminution of its mass. We have then this firm basis to start from: that, viewed as a whole and from the outside, the organism is wholly subservient to the fundamental laws of physics. Its output of matter and energy is identical with the quantities supplied to it; it is in so far analogous to a steam-engine, or any other artefact machine.

After being reluctantly driven to the acceptance of this fact, vitalists were compelled to limit their theories of spiritual control to some abnormal interference with the usual course of redistribution within the organism, an interference which, while not affecting the quantity of energy, yet caused it to evolve in directions opposed to those determined by the laws of physics. They assumed that the "vital force" might co-operate with physical forces within the organism without affecting the energy output. This hypothesis, though destitute of any single fact to support it, is compatible with the conservation of energy, and is, therefore, much superior to the older forms of the vitalistic dogma. Analysis, however, shows us that it is contradictory to other equally fundamental physical laws.

A force is a name for the influence by which any portion of matter tends to alter the direction of motion of any other portion. If the exact distribution of matter and energy be known, then all the forces in operation are also known. That is to say, all mechanical forces are dependent for their existence solely on the immediate distribution of matter and energy; and if this distribution at any moment could be

[1] Rubner, *Die Gesetze des Energieverbrauchs bei der Ernährung*, 1902. Also Atwater, *Reports of British Association*, 1904.

exactly defined, all the forces in operation at that moment would also be given. The appearance of some new force, not involved in the given distribution, would imply the appearance of new matter or of new energy, or the destruction of old matter or energy. If, therefore, the doctrine of the vital force be rendered compatible with the conservation of energy, it is only by a tacit abandonment of the conservation of matter. From this abstract consideration, I now descend to the concrete.

We must suppose that cerebral processes, if reduced to their last chemical analysis, would be resolved, like all other chemical processes, into the motion of atoms. Just as the substance of the brain is built up by an excessively complex grouping of individual *atoms*, so the functions of the brain are the physiological counterpart of the *motions* of these atoms. All cerebral phenomena thus consist ultimately of atomic motions; and any nervous activity is due to a particular kind of motion of atoms in the brain, such motion being, on the mechanistic theory, in harmony with the laws of physics, but on the vitalistic theory, not in harmony with them. If all matter is reducible to atoms, and all energy to matter in motion, we may look upon an atom in motion as the unit of all physical phenomena. The direction of its motion is controlled by the influence of neighbouring atoms, if we accept Newton's first law, viz., that its direction of motion cannot change except by reason of an "external impressed force." Now the vitalist proceeds to assume a new influence *in addition to* that exerted by neighbouring atoms, which, joining in with these, produces a resultant motion in a different direction from what the natural forces would have produced alone. But, as I have already pointed out, force is only a name for stating the mutual influence exercised by atoms upon one another. The assumption of a new force involves, therefore, the assumption of new matter; nay, one of the commonest definitions of matter is "that which can exert, or be acted upon by, a force."[1] Moreover, the allegation of a new force is absolutely meaningless, unless it implies this new matter. For, setting aside all theories, what is the fundamental *fact* alleged by the neo-vitalists? They affirm that an atom in motion may change its direction of motion *without a material cause.* What right, then, have they to use the term "force" to describe this change of motion? All they demand is that motion *is* changed in direction. By saying that a "vital force" is the operative factor, they gain nothing whatever as regards explaining the change of direction, except in so far as they assume the "vital force" to have a material origin. The use of the word "force" is wholly unjustifiable; it gives a fictitious appearance of increased comprehensibility, which appearance can only be attained by deliberately avoiding the consideration of the connotations and meaning of the word "force." It is a verbal explanation; that is to say, it is no explanation at all. If the atom be proved to change its direction of motion in the way alleged, this must be accepted as an ultimate fact, and an exception to Newton's laws. The case is exactly analogous to that of a cannon-ball moving through space which should suddenly change its direction of motion at a right angle, *without any material force or cause whatever.* We may, with the neo-vitalists, ascribe the change to a "celestial force," or we may call it a miracle; we may say that God did it, or that its guiding angel did it; we may *say* what we like, but all we *know* is that the direction of motion is changed, and that our mechanics do not apply. Hence it follows that, if cerebral processes involve something more than mere mechanical interplay, then you must assume one of two things: either that atoms alter their velocity of motion without external cause, in which case you

[1] This, for instance, is the definition given by Lord Kelvin and Professor Tait in their *Treatise on Natural Philosophy.*

traverse the law of conservation of energy, or that they alter their direction of motion, in which case you traverse Newton's laws and the law of conservation of matter.

There is, of course, no *a priori* reason why Newton's laws should not be traversed. It is conceivable that, though they have been found to hold good throughout every department of nature hitherto investigated, they might yet fail in their application to the nervous system. But it is very important to recognize what is really meant by saying that they fail; and in order to facilitate that apprehension, an analogy may be employed.

Although we are not yet aware of the precise nature of the nervous impulse, yet we have no reason to suppose that it involves the transmission of material particles along the nerve. The substance of nervous tissue must be built up from the basis of some kind of physiological unit. I do not know whether this unit is best described as an excessively complex molecule, or as a definite aggregate or combination of such molecules. But, at all events, the nervous tissue owes its peculiar properties to some specific type of molecule or super-molecule of which it is composed, and which constitutes its physiological unit. This unit is so constituted that, when functionally stimulated, the chemical or super-chemical change then induced in it is propagated forwards to neighbouring molecules. Each unit functions momentarily, and is then restored very nearly to its former state of equilibrium. Its functioning infects adjacent units, which likewise pass on the stimulus and themselves promptly return to their original condition. In this manner, a wave of chemical, electrolytic or super-chemical change passes down a nerve, leaving scarcely any permanent traces behind it, and only registering its ultimate effect when it reaches the extremity of the nerve. It then passes into the grey matter of the nervous tissue, where its course is somewhat different. In passing through the grey matter, the impulse apparently leaves behind it larger traces of its passage. It progresses more slowly, owing probably to the necessity of jumping numerous synapses or junctions between nerve-cells. There are a number of other differences (which will shortly be named); but there can be no doubt that the mode of transmission through the grey matter is fundamentally the same as that through a single nerve.

This transmission may be compared to the passage of an impulse down a line of billiard-balls in contact with one another. If we strike the ball at one end of the line in the direction of the centre of the adjacent ball, the impulse will be conveyed down the line till it reaches the ball at the remote end. This ball will then move forwards with a velocity proportional to the force with which the first ball was struck. All the other balls, including that struck, remain motionless. Comparing the balls now to the physiological units of a nerve, we see that the process is analogous in the two instances. In both cases, a stimulus delivered at one end sets up a wave which travels down the line and delivers its effects at the remote end. The intermediate balls, or physiological units, each in turn are thrown into a momentary state of activity, from which they speedily revert to their former quiescence.

The entrance of the current into the grey matter of the spinal cord and brain may likewise be represented by a more complex arrangement of billiard-balls. If, as I assume, the mode of propagation of the impulse is fundamentally the same in the grey matter as in the nerve, it may similarly be represented by the passage of mechanical energy through a system of billiard-balls in contact with one another.

Now the mechanistic theory affirms that any current established within the nervous system proceeds to its natural physico-chemical effects. The vitalistic theory affirms, on the contrary, that a spiritual force co-operating with the ordinary material forces causes it to issue in different results from those which would have been produced by the material forces alone. Referring to the analogy of the billiard-balls, the mechanistic theory asserts that the transmission of the impulse from ball to ball follows the laws of mechanics (discovered or undiscovered). The vitalistic theory, on the other hand, asserts that a departure from mechanical laws takes place. This departure may be visualized in various ways. Either one ball striking another produces no motion in that other, and yet loses its own, or a ball suddenly acquires an impetus of its own without having been struck or acted upon by any external impressed force whatever, or a ball struck by its neighbour in its centre does not move off in the line in which it was struck, but in another line, as, for instance, at a right angle to the line in which it was struck.

Now in practical life we might explain any of these apparent anomalies by reference to imperfections of the table or the balls, or to friction, or some other recognized natural agency. In such cases the anomaly is only apparent: in reality the balls are following their necessary mechanical course, and this course is different from what we expected only because we omitted to take into consideration certain of the mechanical factors engaged. But all errors of this kind are excluded from vitalistic hypothesis. It is the definite axiom of vitalism that the balls do move in a manner inconsistent with mechanics — that is the whole difference between mechanism and vitalism. The case of vitalism may be represented by that of a billiard-ball proceeding to move off on its own account, with a certain velocity and direction, without any kind of material cause whatever, known or unknown.

My purpose in adopting this analogy is to bring home the fundamental inconceivability of the vitalistic position. The particular objection to mechanism which I am here endeavouring to meet, is the difficulty of imagining how any structure of a purely chemico-mechanical basis could account for the infinite varieties and complications of human conduct and morals. Theoretically *any* result may be achieved by a machine; but in the present case the incredible complexity required of the machine is held by vitalists to constitute a very serious difficulty in believing in the reality of the machine-idea at all. They do not appear to recognize that their own rival hypothesis demands a still greater strain upon our credulity. They ask us in effect to conceive a billiard-ball rolling off without any material cause. They ask us to believe that a cannon-ball flying through space may change its direction of motion without the aid of any external impressed force. Such propositions as these attain the highest degree of inconceivability possible to the human mind.

But now a further point arises. Let us suppose that the hypothesis of a vital force, instead of being wholly and unutterably inconceivable, were to be recognized as a possible factor. Let us for the sake of argument accept it, and see to what extent it assists us. The data furnished to us by the nervous system may be typically represented as follows. A stimulus, more or less complicated, affects the sense-organs or terminations of afferent nerves. It is thence conveyed to the central parts of the nervous system, from whence, after a longer or shorter period, it issues in currents along efferent nerves, producing some more or less complicated muscular acts. In a number of cases, as, for instance, where ethical or æsthetic judgments are formed, the central process is deemed by vitalists too complex to be explicable on mechanical principles.

Now let us return once more to the billiard-table, over which is scattered a collection of balls. The nervous stimulus is represented by a new ball entering the system, and there setting up a commotion, while the ultimate effect is registered in two or three balls at the remote end of the system, which travel off, and drain away the energy brought in by the stimulus. Our data, therefore, consist of a knowledge of the incoming ball (its mass, velocity and direction), and also a knowledge of the outgoing balls. Our problem is to ascertain how one gives rise to the other. As already stated, the mechanistic solution supposes that the end-effect is mechanically attained by means of the impulses set up by the incoming ball. The vitalistic solution, while admitting the succession of mechanical impacts, denies that they are adequate to produce the end-effect, and affirms that this effect is attained by means of one or more other balls in the midst of the system which take on a supernatural movement of their own. This motion, joined to the motion mechanically produced, is deemed capable of producing the end-effect.

Does not this hypothesis throw a greater strain upon our imagination than the purely mechanical hypothesis? Consider the astonishing nicety of calculation required to decide the introduced supernatural motion. It is not as though that motion alone was to produce the end-effect: it has to modify ordinary mechanical motion, already highly complex, in such a way that the desired end-effect may be produced. The power which controls the supernatural added motion has not only to estimate the result required, it has also to estimate the existing mechanical motion, and the results which would be wrought by that motion if left to its natural course. It has then to decide what degree of modification has to be inserted in the mechanical motion. Supposing that we have two balls at opposite ends of the billiard-table, and that we have to strike one with a cue in such a way that it shall hit the other at a given velocity and alignment. Mechanism assumes that the ball is struck in the correct way from the first. Vitalism assumes that it is incorrectly struck, and that it moves forwards at a wrong velocity and alignment. Midway in its career, however, the vital force comes into contact with it, and this contact is so delicately arranged that it produces in the original ball just the very modification of motion needed to cause it to strike the final ball at the exact angle and velocity contemplated. This surely is a far more remarkable event than if the first ball had been correctly struck at first.

Very nearly all the arguments adduced against mechanism at the present day are based upon the statement that "it is impossible to understand" how such and such an event could be produced by mechanical means. I therefore wished at the outset to meet that argument by showing that it is much more deadly to vitalistic than to mechanistic theories. I have endeavoured to show, in the first place, that the very notion of a vital force involves a more profound inconceivability than anything in the whole range of mechanism. In the second place, I have endeavoured to show that, even if the vital force were a conceivable and a true agency, its operation would still involve a far higher complexity and elaboration—and therefore a greater inconceivability—than the simple operation of known mechanical forces. The vital force is not only inconceivable by its very nature, but if it were conceivable, its sole effect would be enormously to complicate the immense difficulties of the problem before us. We must then recognize that the difficulty felt by vitalists does not apply to the solution of mechanism, but to the facts themselves. The really startling thing is that these events *do* happen. That would indeed be enough to excite incredulity, did we not witness them at every moment of our lives. Given the facts, there is no *further* difficulty in accounting for them mechanically: if we try to account for them supernaturally, we are simply endeavouring to smoothe away difficult facts by the fabrication of inconceivable theories.

The vitalists have been apt to proceed upon the assumption that the burden of proof lies upon mechanism, and that until mechanism shall be definitely established by experimental methods, vitalism holds the field. It is, no doubt, quite true that the question cannot be settled out of hand by recourse to observation or experiment; if it could be, there would naturally be no occasion for discussion of the subject. The foregoing argument is, therefore, intended to show that, if we are forced to the examination of *a priori* probabilities, every sort of difficulty, or rather inconceivability, blocks the way to a belief in vitalism. Still more powerful considerations, however, may be urged in favour of the view that mechanism is the normal and natural theory of science, while vitalism is not admissible even as an hypothesis.

I have already dilated upon the fact that the human mind tends to explain events from two opposite points of view, materialistic and spiritualistic. I have pointed out that in primitive times the spiritualistic methods were in the ascendancy, and that materialistic explanations were only invoked in those simple cases where their application was obvious and undeniable. With the growth of science and civilization, an ever-increasing category of events became explicable on mechanical principles, and the spiritualistic principles by which they were formerly accounted for fell into disrepute. The advances of materialism, though always unpopular, have always been successful, and the predominance of materialism at any epoch affords the truest possible index to the degree of civilization at that epoch. Materialism was at its height at the zenith of ancient Greek civilization. It declined with the growth of Christianity at the beginning of the Middle Ages. It almost completely vanished—vanished to a degree that is now entirely inconceivable to us—during the blackest period of mediæval times. It revived with the renascence of science and philosophy. It has since grown steadily, notwithstanding the animosity and persecution of religion, and in the present century it has reached a higher point than ever before in the history of the world. The domain of spiritualistic methods formerly included every branch of nature. By degrees the inorganic realm became emancipated, until now, by universal consent, all events of inorganic character are interpreted by mechanical methods. For a long time the rise of materialism scarcely touched the organic realm. Then gradually organic processes fell under the materialistic law of interpretation. Spallanzani disproved the spiritual theory of the process of reproduction. Lavoisier showed that bodily heat was due to oxidation. Up till that time spiritual theories of life had remained almost unquestioned; after that time the opposite schools of vitalism and mechanism came into sharp conflict. Materialistic principles were found to apply to one after another of organic processes. The organism as a whole was proved to be subject to the great laws of physics. Matter was neither created nor destroyed in it. The energy given out from it was identical in quantity with that supplied to it. Organic products, such as urea, were manufactured in the laboratories. At length it was recognized that all the organic processes, to which the experimental method had hitherto been applicable, were based upon mechanical forces. There remained the nervous system, which long seemed too complex for experimental investigation, and which was thereupon proclaimed as the true sphere of spiritual activities. But after a time, experiment began to invade even this sanctified and difficult region. Reflex action was the first to be investigated; and it was soon found that reflex action was wholly and completely mechanical in nature. Further researches disclosed the fact that the nervous system appeared to be built up wholly on the reflex principle; it consisted of a vast and inconceivably complex multitude of reflex arcs, combined and superimposed upon one another, with infinite variety of form and position. And this is how the problem stands to-day. If it is true that mechanism has not yet been witnessed by actual observation of the incredibly intricate regions of the brain, it is nevertheless true that mechanism approaches towards that fortress as near as the perfection of human instruments will allow. It has already conquered the simplest forms of nervous activity, and it has shown that all the more complex forms are compounded from the simplest. This single argument seems by itself to constitute an overwhelming presumption in favour of mechanism, and we have to remember that the argument is only one among numerous others, all converging to the same result. It seems, therefore, certain that any truly unbiassed student will regard vitalism as so excessively improbable an hypothesis, that it could scarcely even be suggested without the support of overwhelming evidence. And when the student further ascertains, not merely that it is supported by no evidence of any kind whatsoever, but that the whole idea of it, when consistently thought out, proves to involve the greatest inconceivability ever dreamt of by man, he will perhaps regard the claim of vitalism to escape the burden of proof as one of the most presumptuous and regrettable incidents in the whole history of human error and superstition.

But the believer in vitalism (it need hardly be said) is not unbiassed. It is obvious that, whatever may be the reason, humanity evinces a strong bias in favour of any kind of spiritual belief. I do not allude merely to the wide generality of religious beliefs. Those beliefs are, indeed, mainly erroneous, as will be admitted by nearly all, even of those who hold them. For whatever sect or religion we belong to, we are in a minority as compared with the totality of other religions prevailing in the world; and if we believe that our own religion is the true one, we *ipso facto* believe that the majority of mankind are in error. It is less to this fact that I refer, however, than to the fact that every materialistic advance has been met with the most vigorous opposition of the Church, the people, and often the civil government. The history of the progress of materialistic science is a history of persecution, and however we may account for it, the fact remains that the normal mind has a strong disinclination towards materialistic doctrines, or, in other words, a strong bias in favour of spiritualistic doctrines. It is this bias which causes vitalism still to be maintained and supported, notwithstanding the extreme discredit into which science and logic have brought it.

On the other hand, the belief in vitalism is least where knowledge of the facts is greatest. The problem of vitalism and mechanism is a problem of physiology; and it is certain that of all classes in the community, the physiologists constitute that with which vitalism finds the smallest favour. Furthermore, it is essentially a problem of the physiology of the nervous system, and it may very safely be affirmed that, among the physiologists who have devoted special attention to the nervous system, over ninety per cent. are warm adherents of extreme mechanism. Belief in mechanism in any class is proportional to the knowledge of the facts prevailing in that class, and it is a remarkable testimony to the strength of the evidence in favour of mechanism, that those possessing special knowledge of that evidence should have been converted from the powerful bias with which they, like other men, originally started.

No doubt this bias is in part founded upon a desire to believe in freedom of will, and moral responsibility, and other cherished convictions which a poor, short-sighted logic supposes to be affected by determinism. To this subject I shall refer later. Men affirm that they are free to do what they like; and, finding themselves unable to calculate what other men will do in particular circumstances, they declare that there exists in the spring of human activities an element of indetermination which is wholly unprophesiable and arbitrary, and never can be brought within the range of a constant scientific formula. This, again, is in contradiction with the facts. It is true that, in the case of one man, it is often quite impossible to say what he will do in some particular collocation of circumstances. A brain is so complex a thing that one cannot in every instance prophesy what muscular contractions will ensue from a given stimulus. That truth does not constitute any evidence of an indeterminate factor, but only of the complexity of the machine. Moreover, the more intimately acquainted we are with the man, the more accurately shall we be able to forecast his behaviour. Knowing the *kind* of activities to which he has been prone in the past, we are able to form, by inductive methods, an approximate opinion as to what he will do in given circumstances. This fact alone suffices to dispel the notion of an indeterminate factor.

Still more evident is this truth when dealing with men *en masse.* We *are* very often able to prophesy within close limits what the public will do in special circumstances. We can form a very accurate forecast as to the number of suicides or the number of marriages that will occur in the course of a year. We can predict what effect the price of corn will have upon these figures. The more accurate our knowledge, the more certainly can we prophesy.

Now all this militates strongly against the idea that there is an indeterminate factor in human behaviour. Such a belief is indeed only consonant with a profound ignorance of humanity. If indetermination was true, we could not reduce human conduct to rules as we do; we could not embody it in formulæ or geometrical curves; statistics would afford no basis for arguing from the past to the future. The more we study, the more industriously we collect statistics, the more deeply we analyze motives and factors, the more accurately are we able to forecast the behaviour of men in bulk. Without this laboriously accumulated knowledge, of course men were bound to believe in an indeterminate element; for then nothing was prophesiable, all was as fickle and arbitrary as the winds of heaven. But as the knowledge increases, the fickleness vanishes; human conduct falls, like all other natural events, into a recognized and regular system. In proportion to our knowledge and analysis of the past, we can prophesy the future; and if we can never attain *absolute* accuracy, the reason is that, as with the winds, we can never co-ordinate the *whole* of the factors engaged, we can never attain to a perfect knowledge of the past.

If the entire activity of all animals, including Man, is due to physico-chemical forces, and if in consequence every animal is an excessively complex machine, the very important problem arises as to the relation of consciousness to this machine. We are accustomed to think of consciousness as a spiritual and not a material manifestation; and we know by constant and immediate experience that a conscious effort can produce a bodily action, that is, a spiritual antecedent give rise to a bodily consequent. We are faced with an apparent paradox: on the one hand, we know by direct introspection that an operation of mind can cause a movement of body; on the other hand, we know that every bodily movement is due to some constellation of purely *material* or physical forces, not capable of modification by any spiritual factor. To meet this difficulty, there have been elaborated the various so-called theories of parallelism between mind and brain. Of these theories, the most popular, as well as the most plausible, is Huxley's theory of epiphenomenalism, according to which mental processes are invariable but inert accompaniments of certain cerebral processes. For every mental state, such, for instance, as a desire to do something, there is a corresponding cerebral state, and the two states vary together in an absolutely parallel manner. When some act is performed, therefore, on the one hand it is preceded by the *subjective* desire to perform the act; this subjective desire is in itself wholly impotent, but it is accompanied by the corresponding cerebral condition, and this condition gives rise to the act by physico-chemical necessary laws. The subjective shadow of mind has no causal influence whatever in the process. It is an absolute superfluity, and the act would be performed just the same whether the subjective accompaniment was present or not. One mental state cannot even cause the next; the cerebral process underlying one mental state gives rise to another cerebral process underlying a new mental state. Thus, while on the surface one mental state appears to have caused another, the true causal sequence has been the unseen but material alterations in the brain, which carry with them parallel alterations in what is called the mind.

I propose to show in Chapter VI that epiphenomenalism, although the most plausible theory attainable to dualism, is nevertheless untenable. We speak of the mind as though it were a thing, and since it is not a material thing, it is regarded as possessing a spiritual consistency. If we can, by a great effort, shake off this paralyzing prejudice—a prejudice which has been immensely fortified and refined by the whole Kantian philosophy—we may still preserve sufficient elasticity to perceive that we know of no such *thing* as mind; we know only of particular states of consciousness, kaleidoscopically varying from moment to moment. What *is* a state of consciousness? The untrained mind will, of course, immediately hypostatize it, and call it a *thing*. Let us, however, call it a process, and instead of regarding it as a thin and shadowy accompaniment of certain cerebral processes, let us boldly identify it with those processes, and say that it is one and the same. Immediately all difficulties vanish. You affirm that you move your arm by an act of will; I affirm that you move it by a cerebral process. We are both right; for the act of will *is* the cerebral process itself.

For the present I wish to do no more than state this theory. I propose to justify it in the final chapter of this book. All that need now be accepted is that there is some sort of immediate and invariable correlation between mental and cerebral processes, a point-to-point correspondence, so that any one kind of mental condition necessarily implies some specifically corresponding kind of cerebral condition. Whether we regard the relation as one of identity or of simple parallelism is of little importance at the present stage. The law of correlation, in either case, insists that psychology is subordinate to physiology, and that if the physiology of the brain and nervous system were entirely understood, the coexistences and sequences of mental states would also become clear. It appears, moreover, that, even in the existing state of physiology, a great many mental processes are explained far more easily by reference to physiology than by pure psychology alone. It is to the physiological aspects of the mind that I shall devote the remainder of this chapter.

Psychologists divide mental processes into three main groups: intellect, emotion, and will. The definition of these groups is not easy. Emotion seems to possess *intensity* as its fundamental characteristic. Although it is commonly associated with pleasure and pain, there is probably no necessity for such a relation. Some very powerful emotions—such, for instance, as surprise—may be free from any pleasurable or painful colouring. Emotion is essentially an intensive nervous condition, and physiologically we may suppose it to be characterized by extremely rapid molecular change, or by intense functioning in the region of the nervous system with which it is correlated.

Intellect, on the other hand, is mainly characterized by *extensity*. Intellectual processes take place by means of association. In the brain we must suppose a network of associative bonds to be the correlate of intellect. Innumerable nerve-cells become bound together by threads of communication, or by suppression of resistance at the synapses, and function jointly. These lines of communication are not so much material links as passages of easy transit, which enable large areas to function as consolidated single units.

The mental category of will corresponds to the cerebral process by which muscular activity is initiated in certain kinds of complex situations. All these main divisions of the mind are characteristic of the higher animals only. They are all three highly evolved and differentiated out from one common origin. In the most elementary forms of life, the organism represents a little storehouse of energy. There is no nervous system, but the entire protoplasm possesses in a rudimentary degree the properties of nerve. The corresponding rudimentary consciousness which we must attribute to these animals is therefore correlated, not with the functioning of any specialized tissue, but with the entire body of the animal. At first an external stimulus causes contraction, and this must be regarded, not only as the archetype of all nervous action, but also as the beginning of all conscious processes. Later in evolution, the stimulus is conveyed to a central exchange, from whence it emerges to a particular portion of the body, which portion alone contracts. We here have at least five stages in the process: stimulus, afferent conduction, central process, efferent conduction, and contraction. From these rudiments, the whole of the higher consciousness of Man is ultimately evolved.

In the main the differentiation of various types of consciousness is due to the enormous elaboration of the central process. When the stimulus, on reaching the central ganglia, there sets up very intensive processes with vague boundaries, we have what is called emotion. When, on the other hand, it sets up very extensive processes with relatively precise boundaries, we have what is called intellection. When it passes rapidly through the centre, without setting up any unusual activity, we have to do with reflex or other automatic action. The fundamental fact about nervous activity is always a stimulus, afferent conduction, central process, efferent conduction, muscular or glandular action. In simple animals, these various elements are tolerably obvious. In complex animals they are not. The central process becomes so elaborate as often completely to obscure the fundamental sequence of events; it is often impossible to name the stimulus or the final action. The activity of the nervous system is concentrated to a high degree in the central regions. The cerebral hemispheres absorb the powers of the system; the other elements in the chain of events are swamped and lost sight of.

The evolution of the nervous system, and hence of conscious processes, does not betray, therefore, any departure from the original scheme, in which a stimulus from without gives rise to conduction, central process, further conduction, and finally action. The difference between the primitive and developed nervous systems is found mainly in the fact that in the primitive system the central process is comparatively insignificant, whereas in the developed system the central process overwhelms the rest, and is very often the only discernible process occurring. Thus in emotion the incoming currents set up a process of *intensive* molecular change in the central regions. In intellection, the central activity is less violent, but far more definite and precise: it involves *extensive* molecular change. In reflex action and simple nervous processes the impulse may run through the central regions without causing any great commotion there, as in primitive animals. Primitive animals can have only one kind of consciousness, subject only to slight variation, because there is little variation in their central processes, which, so to speak, are neither deep enough to constitute emotion, nor wide enough to constitute intellect.

In substantiation of these various propositions, I shall proceed by the institution of two sets of comparisons. In the first place, I shall compare the conductivity of a simple nerve with the conductivity of a reflex-arc. In the second place, I shall compare elementary conscious processes with advanced conscious processes. The main difference between a nerve-trunk and a reflex-arc is that the former includes no central grey matter, whereas the latter does. The grey matter of a reflex-arc must contain at least one synapse as a theoretical minimum. Moreover, seeing that the whole nervous system is built up by a multi-composition of the reflex principle, it is a sure assumption that the highest nervous processes differ from the process in the reflex-arc in the same way that conductivity through the reflex-arc differs from nerve-trunk conductivity. In the highest nervous processes the grey matter is enormously increased, and the impulse has to be conveyed past a multitude of synapses. It follows that the difference of these highest nervous processes from nerve-trunk conduction is of the same kind, though greatly intensified, as the difference of reflex-arc conduction from nerve-trunk conduction. If, as I have said, there is a point-to-point correspondence between mental and cerebral processes, it follows further that the differences between the higher and lower mental processes should present an exact counterpart of the differences between reflex-arc conduction and nerve-trunk conduction. Let us now inquire whether this expectation is justified by the facts. I shall deal in turn with the eleven salient points of difference between reflex-arc conduction and nerve-trunk conduction, as given by Prof. Sherrington in his *Integrative Action of the Nervous System.* The general purpose is to indicate the correspondence existing between nervous activity and mental activity. Prof. Sherrington enumerates the differences between a higher and a lower form of nervous activity. This is the *nervous aspect.* To each of his eleven points of differentiation I append the *mental aspect*, with a view to showing that mental complication and nervous complication pursue absolutely parallel paths.

Nervous Aspect. (As stated by Prof. Sherrington.)	*Mental Aspect.*
(1) Conduction in reflex-arcs is slower than in nerve-trunks.	Higher mental operations are slower than the simple ones. Intellect is slower than instinct; voluntary action slower than automatic action.
(2) In reflex-arcs there is less close correspondence between the moment of cessation of stimulus and the moment of cessation of end-effect; there is a marked after-discharge.	The higher manifestations of mind have grown out of all relation to their stimulus and end-effect. Intellectual operations may be initiated by a stimulus or set of stimuli received long previously, and they may issue in action only after a protracted period. In

Nervous Aspect.	*Mental Aspect.*
	lower mental operations there is a far closer time-correspondence between stimulus and reaction.
(3) Less close correspondence in reflex-arcs, between rhythm of stimulus and rhythm of end-effect.	The mental homologue is as noted above.
(4) In the reflex-arc there is less close correspondence between the grading of intensity of the stimulus and the grading of intensity of the end-effect.	A most marked characteristic of higher consciousness. So slight a stimulus as a short sentence or even a word, softly applied near the auditory nerve, may produce the most violent mental reaction, whereas an expected explosion near by may have very small effect. In lower mental types, no such incongruity exists between stimulus and reaction.
(5) The reflex-arc, as compared with a nerve-trunk, presents considerable resistance to the passage of a single nerve impulse, but a resistance easily forced by a succession of impulses.	The mental correlate of this is found in the capacity of the higher regions of the mind for education. Repetition is one of the most essential requirements for learning. In the case of instinct, on the other hand, repetition has comparatively slight effect.
(6) Irreversibility of direction in reflex-arcs, as against reversibility in nerve-trunks.	The application of this to conscious processes is obvious.

Nervous Aspect.	*Mental Aspect.*
(7) Fatigability as against relative infatigability in nerve-trunks.	The higher processes of intellect and emotion are very exhausting, and induce fatigue far earlier than the lower conscious processes.
(8) Greater variability of the threshold value of the stimulus.	Mental processes are called forth by stimuli, varying from those that are so great as scarcely to be bearable, down to those that are so small as to be far beneath the power of measurement (*e.g.* olfactory stimuli).
(9) Refractory period, "Bahnung," inhibition, and shock.	All these are eminently characteristic of the higher mental processes. Inhibition and "Bahnung" (the converse of inhibition) are the main features of the higher mental process called attention. They are enormously involved in emotion, as well as in intellect.
(10) Much greater dependence on blood-circulation, oxygen, etc., of reflex-arcs than nerve-trunks.	All the higher mental processes are instantly dependent on these requisites; and impoverishment of the blood-supply has a marked effect in reducing the power to support either emotion or intellect.
(11) Much greater susceptibility to various drugs, such as anæsthetics.	Alcohol temporarily destroys the higher mental powers, before it reaches the lower. Chloroform wholly blots out the higher mental life, while yet the lower reflexes remain intact.

From these eleven points of comparison, we see that the higher mental processes differ from the lower in precisely the same way that the reflex-arc differs from the nerve-trunk. The higher mental processes are correlated with the development of grey matter in the brain, or at least with the complexity of nerve-cells and synapses which characterize that grey matter. Thus we have on the physical side a series of functional units of increasing complexity—nerve-trunk, reflex-arc, central nervous system. On the mental side there is a corresponding series of ascending complexity—automatic action, instinct, and fully developed intellect or emotion. In both series the signs which characterize increasing complexity are the same. Nervous development and mental development pursue exactly parallel lines.

The main purpose of this chapter is to emphasize the fact that the higher conscious life does not involve any new factors or any different principles from those in operation in other departments of Nature. The organism, whether animal or plant, is a little vortex of matter and energy formed here and there in the incessant stream of distribution and change. Men think, feel, and act as they do as a necessary result of their physical, and especially of their nervous conformation, this conformation being determined by heredity, slightly modified by acquirements subsequent to birth. Slight though these modifications intrinsically are, they are of first-rate importance relatively to human conduct. For in all essentials the conduct of men never varies, if we compare it, for instance, with the conduct of a frog or of a starfish. Human conduct is fundamentally the same all the world over, because the structure of the human body is the same—because the human race is one species or protoplasmic type. The differences of conduct among men only appear great when we take the main hereditary basis for granted, and fix our attention wholly on the divergences of the surface. The organism is a machine, whose function is that of energy-transformation. A stimulus set up upon the surface works internal changes, which issue in action. That is to say, energy absorbed from without is transformed into other kinds of energy according to the common laws of physics and chemistry. The precise manner of transformation depends upon the structure of the organic machine.

Moreover, the organism contains within itself a very concentrated fund of energy. As a consequence of this, in higher organisms, all direct relation is lost between the incoming and outgoing energy. Energy may continue for a period to be stored up by anabolic process, much in excess of what leaves the organism. And then a very small external stimulus may act like a spark on gunpowder, and energy may be released with katabolism at a higher rate than it is absorbed. All this depends upon organic structure.

Many persons condemn the mechanistic doctrine on altogether irrelevant grounds. If human conduct is totally determined by structure and environment, what, they ask, becomes of moral responsibility and free-will? Why are we not fatalists? To this there are two answers. The first is, that we are searching for the *truth* of the matter, independently of its moral effects upon the human race. *If* the truths of physiology are such as to undermine moral responsibility, it might constitute an argument for suppressing physiology, or preventing the propagation of its truths among mankind, but it constitutes no sort of argument for denying the truths themselves. If moral responsibility is a superstition, the mere fact that it is an exceedingly useful one does not make it any the less a superstition.

But the second answer is that the truths of physiology, so far from undermining moral responsibility or freedom of will, provide them with a far stronger support than they have ever had before. The belief that physiological mechanism results in fatalism is due to a very imperfect comprehension of the doctrine. Fortunately there is no occasion to argue on a matter which can be settled by direct observation. Materialism in history has never yet been associated with fatalism, nor has any mechanist ever been a fatalist. Fatalism, on the other hand, is characteristic of the highly spiritualistic religions of various Eastern races. Moreover, the Church doctrine of Predestination is far more open to the charge of fatalism than is any theory of physiology or logic.

Many are repelled by the doctrine that an animal can be physically analogous to a machine; and, curiously enough, those objectors are chiefly found among those who entertain the opinion that animals are made by an all-powerful Deity. But surely if Man can make machines of a simple kind like the steam-engine in order to convert energy, could not an all-powerful Deity make machines of the immeasurably more complex kind called an animal? The *principle* is the same, and that only. The difference is one of complexity. Can we set limits to the complexity of a machine made by an all-powerful Creator? A machine does not resemble an animal more than a candle-flame resembles the Sun. We are dealing only with an immeasurable complication of the simple patterns that can be appreciated by our imagination. In the Universe as a whole we dealt with infinite greatness; in the constitution of matter we were confronted with infinite smallness; in conscious life we find infinite elaboration and complexity; but underlying all these are the same unitary principles at work. There is nowhere any suspension of physical law; there is nowhere any goal or purpose to which things are directed; there is nowhere any spiritual agency to affect the blind interplay of natural forces.

CHAPTER V

MATERIALISM

In the four preceding chapters we have surveyed the present position of scientific knowledge in so far as it is relevant to constructive philosophy. We have extracted, as far as possible, such facts and theories from different branches of science as can furnish data to philosophy. Philosophy of necessity is rooted in science; but it does not follow that *all* the doctrines of science possess some philosophic import. Many of them are more or less isolated truths of no special significance, other than what appears on the surface. Many of them, on the contrary (and they are those which we have endeavoured to present in the foregoing chapters), possess a deeper significance than the bare facts which they enunciate. They are items in natural knowledge like the rest; but they are items which may be used as bricks in the building of a larger edifice. They help to furnish us with a wider view over the landscape of Nature; not, indeed, to solve any ultimate mysteries—that is the putative province of metaphysics and theology—but to indicate a few laws of wide generality, such as may properly be called philosophic. The induction of philosophic principles from scientific doctrines can at present only be carried on to an extremely limited degree. The conclusions that emerge—however limited they may be—are the sole clue that we can ever have to the mysteries of life and existence. They are infinitesimal enough, no doubt, but beyond them all is darkness.

To any individual or any society which has had no experience or education, the world simply presents a disordered medley of objects and events. The objects are heterogeneous, unclassified and meaningless; the events are a clash of unruly forces, for which no cause is assignable and no future consequence deducible. At this stage of development, mankind, like any of the lower animals, lives exclusively in the present, and, in fact, is unconscious either of a past or of a future. The whole mental content, the whole Universe, for such a mind is comprised in the objects and events which for the moment are in occupation of consciousness.

Among the individuals of civilized communities this primitive mental condition is passed at quite an early age. One of the earliest symptoms of the growing enlightenment is the child's inquiry how it came into the world, and where it was before it was born. Already the life, limited to the present consciousness, has begun to dissipate. Soon new problems arise, acquaintance is made with the fact of death, and the child begins to speculate what happens to it after death. As it grows older, and gradually comes to realize the inevitableness of its own death, the question of its fate after death becomes one of enthralling interest, which almost entirely eclipses the problem of its past career before birth. And so new problems are continually opening out as the mind develops. Our lives fill a span of a few years in the midst of infinite time. Our world is a great spheroid of matter, set in the midst of infinite space. We can flit in imagination from one star to another in a moment of time. It does not take a second to transfer our thoughts from the room we sit in to the great nebula in Orion. But however vast the distances we can thus traverse in imagination, no imagination serves to bring us any nearer to a boundary of space, or to a beginning or end of time.

It is from speculations of this character that philosophy took its rise. And the result of inquiry has commonly been that new problems rise upon the intellectual horizon faster than the old problems are solved or otherwise disposed of. Hence there is collected a vast sphere of inquiry and speculation, of immense human interest, to which we give the name of philosophy. In early times all such questions are answered almost as soon as they are asked. A primitive people cannot brook the Agnostic attitude; they must have an answer, and there are no rules of logic to limit their methods; hence they leap at anything, however absurd, that offers some escape from the unpleasant hesitation and confession of ignorance that are forced upon a more educated intellect. Mythologies spring up in company with grotesque systems of physics and metaphysics, which, however little they may have in common with truth, and however far they may be from possibility of verification, at all events relieve that suspense which is so intolerable an attitude to the undisciplined mind.

It thus comes about that civilization receives from the past, not only an immense number of philosophical problems, but a more than corresponding number of solutions. Now, putting aside the question as to whether many of these problems are or are not soluble, it is certain that the early solutions presented are erroneous, or even meaningless. A first result of scientific training, therefore, is the acquisition of a position of Agnosticism or scepticism. Just as, in the ordinary affairs of life, the untrained mind can with difficulty be restrained from injudicious meddling; just as, in many of the more difficult situations of practical life, it requires a far higher knowledge and mental calibre to remain still and to do nothing than to do something, when action is more likely to bring evil consequences than good; so, in the philosophical sphere, the conscious recognition of impotence to deal with some problem implies and requires a far higher mental development than the prompt adoption of one or other of the many solutions commonly proposed from several sides. Hence it is that with enlightenment comes a great contraction of the sphere of problems to which answers are given. There is an ever-increasing differentiation between the problems of science and the problems outside science. Formerly all such problems received solutions, and they were in most cases full of inaccuracy or error. The purging of error is a difficult, and always an unpopular, process. Now the problems of science receive solutions which commonly attain a high degree of accuracy and permanence. The problems outside science, on the other hand, come in many cases to be regarded as insoluble. The area of inquiry adopted by the ancients has been divided by the moderns into two very distinct regions. In the one, answers are furnished which greatly surpass those of the ancients in fullness and in accuracy; in the other, few answers are furnished at all—scepticism reigns in striking contrast to the luxurious speculations of the past.

The majority of philosophers hold that there are other means to knowledge besides those of natural science: they have not yet lost faith in the methods of metaphysics. When, however, we compare the fertility of science with the barrenness of metaphysics during the last two or three thousand years, we cannot discern the smallest claim on the part of metaphysics to any recognition as a means for the discovery of truth. Metaphysics is like a house built upon the sand; its foundations are for ever shifting with every new exponent of the art. Science is like a house built upon a rock; so firm are its foundations that each generation of workers adds a new storey to the edifice. We cannot admit, therefore, that metaphysics is a rival method to science, but regard it rather as a study of the same order and validity as theology. Only by the methods of science can knowledge be attained; any other point of view than the scientific is worse than useless, since it leads not to knowledge, but to pseudo-knowledge. Our only hope of any real constructive philosophy lies in gathering together and co-ordinating the larger principles that emerge from a study of science.

I am fully aware of the prejudice against any sort of constructive efforts that exists in the minds of many who, like myself, believe in no other means of attaining truth than those of natural science. I venture to believe, however, that the position of extreme Agnosticism is inclined to be overdone by a very natural reaction against the exaggerated claims of metaphysics and theology. It is inferred that, because so many futile inroads on philosophy have been made by these ancient but discredited methods, therefore no discussion of philosophical problems can ever lead to solid results. This question, after all, depends very much on the definition to be attached to the word philosophy. I shall not, indeed, attempt to give it a formal definition: the body of the present work will itself constitute the best definition of what I mean by philosophy. There appears to me no sharp division between science and philosophy. The name philosophical is applicable to those wide theories of science, such as that of natural selection, by which vast quantities of isolated facts become connected together, or to some extent "explained." The bare collection of facts which remain solitary and meaningless is not philosophy. The co-ordination and interpretation of those facts by the formulation of general laws and principles is philosophy. We may have a philosophy of science, just as we may have a philosophy of history. In the case of history, the raw material consists of bald facts—of dates, events, battles, names of kings, etc. —which to an unintelligent mind is a mere chronicle of time, carrying no information other than what is included in the plain recital of the facts. But the philosophic historian, such, for instance, as Tacitus or Gibbon, co-ordinates the facts, seeks out causes, draws inferences, and endows the whole subject with life and fire. They learn from their studies far more than is borne upon the face of the facts they deal with, and their knowledge of the past becomes of great value for the present, if not for actually prophesying future events, at least for determining the kind of results which are likely to flow from the establishment of various kinds of social institutions.

In just the same way the dry bones of science are animated by an infusion of the philosophic spirit. It does not follow that because metaphysics has vainly endeavoured to explain the Universe, therefore every kind of philosophical theory must be false. This would be to argue that because we do not believe in Plato, therefore the law of gravitation is untrue. Doubtless, as I have said, the matter is largely one of definitions. If by philosophy we mean an inquiry into the origin of the Universe, then it should be severely discarded. By philosophy I mean those inquiries of the widest interest, which can be approached and dealt with by the same methods as those obtaining in natural science. Philosophy does not occupy a sphere outside science, any more than in the case of history there is a separate department of philosophy. In both cases philosophy is a method of treatment, not a separate subject. I use the term to denote those operations which are carried out *after* the requisite facts have been collected. Both in science and in history we must begin by the simple accumulation of facts, and, meanwhile, we must remain philosophically agnostic. When we have got our raw material of facts, we can then begin to co-ordinate and classify them, that is to say, introduce the philosophic method. Without some such philosophic treatment the facts remain useless and uninteresting, science cannot be brought into the service of humanity, nor can true knowledge be advanced. No one would be interested to hear that the 542nd word of this chapter is "the." It is or may be a bald fact, devoid of philosophic significance, and no accumulation of such facts could ever constitute genuine knowledge. As in the arts, and as in history, our raw material is of no use to us until it has been properly worked up. We have to apply the processes of synthesis and analysis, which illuminate the facts brought in by the workers, give them life and meaning, and suggest lines of research for the discovery of other facts in corroboration or the reverse.

The main purpose of the present work is to defend the doctrine of materialism. It is, indeed, a materialism infinitely different from that of the ancients, for it makes vast concessions to Agnosticism, and it concedes the whole foundation of knowledge to idealism. Yet it remains materialism; for I shall endeavour to show that the whole of the positive knowledge available to mankind can be embraced within the limits of a single materialistic system. The outlines of this system are not new; the main features of it, indeed, have been admittedly associated with scientific progress for centuries past. An age of science is necessarily an age of materialism; ours is a scientific age, and it may be said with truth that we are all materialists now. The main principles which I shall endeavour to emphasize are three.

1. The uniformity of law. In early times events appeared to be entirely hazardous and unaccountable, and they still seem so, if we confine attention purely to the passing moment. But as science advances, there is disclosed a uniformity in the procedure of Nature. When the conditions at any one moment are precisely identical with those which prevailed at some previous moment, the results flowing from them will also be identical. It is found, for instance, that a body of given mass attracts some other body of given mass at a given distance with a force of a certain strength. It is found that when the masses, distances, and other conditions are precisely repeated, the attraction between the bodies is always exactly the same. It is found, further, that when the distance between the bodies is increased the force of their attraction is diminished in a fixed proportion, and this again is found to hold true at all distances at which they may be placed. The force of their attraction again varies in a different but still constant proportion to their masses. And hence results the law of gravitation, by which the force of attraction can be precisely estimated from a knowledge of the masses and distances between any two bodies whatever. A uniformity is established which remains absolute within the experience of Man, and to an equivalent extent the haphazard

appearance of events is found to be only an appearance. Innumerable other laws of a similar character are gradually discovered, establishing a sort of nexus between every kind of event. If oxygen and hydrogen in the proportion by weight of eight to one are mixed together, and an electric spark is passed through them, water is formed; and on every occasion where precisely the same conditions are realized precisely the same result ensues. This truth is the basis of the experimental method. If from similar conditions it were possible that dissimilar results should follow on various occasions, then experiments would be useless for advancing knowledge.

This uniformity of sequence confers the power of prophesy; and the more we learn about the nexus of natural phenomena, the greater becomes our power of prophesying future events. Such prophesies are made and fulfilled at the present day in all departments of knowledge where the data or conditions are sufficiently few and simple to be dealt with by calculation, as, for instance, in many astronomical problems. They are made even when the data are numerous and complicated, though with much less accuracy. We can foretell at what minute on what day an eclipse of the Sun will begin to take place. We can equally foretell that a rise in the bank-rate will, under normal conditions, cause an influx of gold; but precisely how much gold we cannot tell. With a larger knowledge of the conditions, we could arrive at a closer approximation to the amount of the influx. With an absolute knowledge of all the conditions at work, we could prophesy the exact number of ounces of gold that any specified rise of bank-rate would divert into this country. Such a knowledge, of course, is for ever impossible, since the factors concerned are innumerable and severally minute; to apply mathematical analysis to them, even if they could all be collected, would infinitely transcend our powers. Nevertheless, we shall be led to adopt the proposition of Laplace,[1]

[1] *Essai Philosophique Sur Les Probabilités,* 1819, p. 4.

to the effect that if we knew the precise disposition at any moment of all the matter and energy existing in the Universe, and the direction of motion of every moving particle, and if we were armed with a mathematics of infinite power, we should be able to prophesy the exact disposition of all the matter and energy in the Universe at any future time. Any being who possessed such powers, and who, a myriad ages ago, had acquired absolute knowledge at some moment of the nebula from which the solar system arose, would have been able to prophesy that at this present moment there would exist a being identical with myself who would be writing the words that are now flowing from my pen; he would have been able to prophesy that a little later other beings, identical with my readers, would be perusing those words, and he would be aware of what emotions would be excited within them by the perusal. In other words, the uniformity of Nature and the paramountcy of law are universal and without exception.

2. The denial of teleology. Scientific materialism warmly denies that there exists any such thing as purpose in the Universe, or that events have any ulterior motive or goal to which they are striving. It asserts that all events are due to the interaction of matter and motion acting by blind necessity in accordance with those invariable sequences to which we have given the name of laws. This is an important bond of connection between the materialism of the ancient Greeks and that of modern science. Among all peoples not highly cultivated there reigns a passionate conviction, not only that the Universe as a whole is working out some pre-determined purpose, but that every individual part of it subserves some special need in the fulfilment of this purpose. Needless to say, the purpose has always been regarded as associated with human welfare. The Universe, down to its smallest parts, is regarded by primitive superstition as existing for the special benefit of man. To such extreme lengths has this view been carried that even Bernardin de Saint-Pierre,

who only died last century, argued that the reason why melons are ribbed is that they may be eaten more easily by families.

The reason for this early teleology is obvious. We all of us survey the Universe from the standpoint of our own centrality. Subjectively we all do stand actually at the centre of the Universe. Our entire experience of the Universe is an experience of it as it affects ourselves; for if it does not affect ourselves, we know of it only indirectly, and in primitive stages we do not know of it at all. As our education endows us with a wider outlook and a wider knowledge, we come to see that the objective Universe is very different from our own private subjective Universe. At first we discover that we as individuals are not the centre of the Universe, as appears to uncorrected experience, but that we are merely one individual among many others of equal status constituting a nation or society. We then perhaps regard our own society as the centre of the Universe, as many primitive peoples do, such, for instance, as the ancient Romans and the modern Chinese. Or we may regard our own sex as the purposed product of the Universe, as in many Mohammedan peoples, who hold that women have not souls like men, and that they exist purely for the benefit or use of men, in the same way that cattle exist in order to be eaten, or that melons are ribbed to indicate the proper amount of one portion.

With still further cultivation, the entire human species becomes regarded as the centre and object of all events in the Universe. This is the stage now reached by the masses in modern civilizations. Just as the existence of one particular individual has not the world-wide or cosmic importance that that individual is apt to suppose; just as the existence of a particular tribe or society is not of the profound historic import that that tribe or society very commonly imagines; so too the human species as a whole is far from being, as it too often believes, the sole object for which the Universe was created, with all things in it, great and small. The human species is, indeed, a mere incident in the universal redistribution of matter and motion; its existence has not the smallest cosmic significance. Our species is biologically very modern. Neither in numbers nor in antiquity can it compare with infinitely numerous species of other animals inhabiting the Earth. The Earth itself is one of the smaller planets, revolving round a minor star. The entire solar system, of which the Earth is so insignificant a portion, is itself a system of contemptible minuteness, set among other luminaries and other systems which surpass it many times in magnitude, in brightness, and in every other ascertainable quality that we are accustomed to admire.

When it is alleged that the Universe is purposive, it is assumed that humanity is intimately connected with the purpose. Without that assumption, none but the most transcendental of philosophers would have any interest in maintaining teleology. As the anthropocentric doctrine falls, therefore, the doctrine of teleology must fall with it. This, at all events, is the position taken up by scientific, as indeed by all materialism; it is the position that I hope I shall have little difficulty in defending in the following pages. Nevertheless, however obvious its truth, we must recognize that it involves a profound alteration in the existing mental point of view of the majority of mankind; for most men have as yet not shaken off the habit, which all men necessarily start from, that they themselves, or their family, nation or kind, are in fact, as in appearance, the very centre of the cosmos.

3. The denial of any form of existence other than those envisaged by physics and chemistry, that is to say, other than existences that have some kind of palpable material characteristics and qualities. It is here that modern materialism begins to part company with ancient materialism, and it is here that I expect the main criticisms of opponents to be directed. The modern doctrine stands in direct

opposition to a belief in any of those existences that are vaguely classed as "spiritual." To this category belong not only ghosts, gods, souls, *et hoc genus omne*, for these have long been rejected from the beliefs of most advanced thinkers. The time has now come to include also in the condemned list that further imaginary entity which we call "mind," "consciousness," etc., together with its various sub-species of intellect, will, feeling, etc., in so far as they are supposed to be independent or different from material existences or processes.

I beg that the reader will not hastily repudiate a suggestion which, until rightly understood, must appear almost as absurd as did Berkeley's original formulation of idealism. It seems to the ordinary observer that nothing can be more remotely and widely separated than some so-called "act of consciousness" and a material object. An act of consciousness or mental process is a thing of which we are immediately and indubitably aware: so much I admit. But that it differs in any sort of way from a material process, that is to say, from the ordinary transformations of matter and energy, is a belief which I very strenuously deny, and which I propose to discuss and elucidate at length in my final chapter. The proposition which I here desire to advance is that every event occurring in the Universe, including those events known as mental processes, and all kinds of human action or conduct, are expressible purely in terms of matter and motion. If we assume in the primeval nebula of the solar system no other elementary factors beyond those of matter and energy or motion, we can theoretically, as above remarked, deduce the existing Universe, including mind, consciousness, etc., without the introduction of any new factor whatsoever. The existing Universe and all things and events therein may be theoretically expressed in terms of matter and energy, undergoing continuous redistribution in accordance with the ordinary laws of physics and chemistry. If all manifestations within our experience can be thus expressed, as has for long been believed by men of science, what need is there for the introduction of any new entity of spiritual character, called mind? It has no part to play; it is impotent in causation. According to Huxley's theory it accompanies certain physical processes as a shadow, without any power, or any reason, or any use. The world, as Huxley and the great majority of physiologists affirm, would be just the same without it. Now there is an ancient logical precept which retains a large validity: *entia non sunt multiplicanda præter necessitatem.* It is sometimes referred to as William of Occam's razor, which cuts off and rejects from our theories all factors or entities which are superfluous in guiding us to an explanation. "Mind" as a separate entity is just such a superfluity. I will not deny—indeed I cordially affirm—that it is a direct datum of experience; but there is no direct datum of experience to the effect that it is anything different from certain cerebral processes. If uneducated experience seems to deny the identity, the denial rests upon an inference or deduction which is just as faulty as was the denial of Berkeley's theory that what we call matter is no more than sense-impressions. In passing, I may point out the difference here disclosed between modern scientific materialism and the crude materialism of the ancients. They agree in declaring the uniformity of law; they agree in denying the doctrine of teleology; they agree that all existences are of a material character. But they disagree in their treatment of the alleged spiritual and unseen world. The ancient materialists believed to a certain extent in an unseen world; they believed even in the existence of souls. They asserted their materialism only by the theory that these entities were material in character. Democritus conceived the soul as consisting of smooth, round, material particles. The scientific materialist of to-day does not believe in any separate existence of this kind whatever. He regards what is called soul or mind as *identical* with certain physical processes passing in a material brain, processes of which the ancient Greeks knew nothing, and, indeed, which are still entirely unknown to all who have not acquired some smattering of physiology.

That materialism is the basis of all *science* is a proposition that many, if not most, philosophers would readily admit. That it is the basis of all *knowledge* is a more comprehensive proposition, which the majority of philosophers would certainly deny. Yet this more comprehensive proposition follows necessarily from the first, if once it is admitted that there can be no knowledge save that derived from the ordinary methods of natural science—observation and experiment. A materialist may, and indeed must, admit that "feeling" or some "conscious" state is the original material of the whole of our experience, when analyzed down to its extreme depths. He must further admit that matter is not, like feeling, an elementary datum of experience, but that it is built up by invariable associations of conscious elements. In short, matter is made of feeling, as Berkeley said; matter is clotted consciousness; it is a derivative of acquired experience, precisely of the same order as time and space. It may be regarded, like time and space, as a form of thought. With them it is the foundation of all that vast body of associations and inter-relations that we call knowledge, and when more highly organized, science. I do not for a moment defend materialism in a metaphysical sense, as would be the case if I were to affirm that matter is an ultimate fact, reducible to no lower or more recondite elements. Far from it. Idealism holds the field, but scientific materialism *does not conflict with it*, as crude materialism has always done. Out of the raw and meaningless "experiences" of the infant, there gradually evolve a set of constant associations which in course of time swell up and form the sum-total of the individual's knowledge. This set of associations is based upon those very early ones in which sensations of colour, touch, etc., are combined to yield the generalized idea which is called "matter." To this any one may assent. The peculiarity of the materialist is to affirm that no new knowledge can be acquired except by association of new experiences with the great sphere of associations already established on the basis of matter, time and space. There cannot be isolated wisps of knowledge, wholly unassociated with the main body, any more than there can exist in an animal a single elementary reflex-arc, not integrated up with the nervous system; and the comparison is far more than a mere analogy. I must, however, leave this difficult subject for the present.

The materialism which I shall advocate, therefore, is centred round three salient points: the uniformity of law, the exclusion of purpose, and the assertion of monism; that is to say, that there exists no kind of spiritual substance or entity of a different nature from that of which matter is composed.

The first of these propositions, otherwise called the Law of Universal Causation, affirms that nothing happens without a cause, and that the same causes under the same conditions always produce the same effects. In order to gain a true comprehension of this law, we have to define what we mean by "cause" and "effect," and what is the nature of the nexus between them. The conception of the Universe from which we start is that of a great system of matter and motion undergoing redistribution according to fixed sequences, which in the terminology of science are called laws. The matter is constantly undergoing transformation from one of its forms into another, and the energy is redistributed and transformed in a corresponding manner. From this primary conception alone, we are able to derive a precise definition of what is meant by cause, a problem which is almost insuperable from any other standpoint. Mill defined one event as being the cause of another when the first event is found invariably in experience to be followed by the second. In cause and effect he saw nothing further than an invariable sequence. His view was at once demolished when he was asked whether he considered that day was the cause of night, for this also is a sequence invariable in our experience. But if we apply analysis, the difficulty vanishes. If we regard an event as a momentary phase in the redistribution of matter and motion, then the cause of the event is found in the immediately preceding state of distribution of that same matter and motion. Let us ask, for instance, what is the cause of the sudden appearance of a new fixed star in the heavens. Supposing that there were previously two extinct suns moving rapidly towards each other and coming into collision, we should be making a statement of events which would be recognized as a possibly true "cause." The second event, or "effect," is represented exclusively in terms of matter and motion by the idea of two coalesced and volatilized bodies giving rise to vast quantities of heat and light. And the cause is given merely by stating the previous distribution of that matter and energy which is concerned in the production of the event. The *matter* concerned in the event consisted of two solid bodies at a rapidly diminishing distance from one another. The *energy* consisted of half the product of their momentum and velocity. By the collision the matter contained in the solid bodies underwent that redistribution involved in passing into a gaseous state, with the decomposition of many of its molecules, that is to say, with a rearrangement or redistribution of its atoms. The energy of motion previously contained in the solid bodies underwent at the same time a transformation into heat and light. The sudden light, therefore, is explained, or derives its cause, merely by furnishing a statement of the previous distribution of the matter and energy concerned in its production.

Let me now take a slightly more complex instance, that, namely, of a specific bacillus as the cause of tuberculosis. What is the cause of tuberculosis? The disease is characterized by lesions of a specific type, which may occur in very various parts of the body. The effect, therefore, or the tuberculous condition, may be analyzed into a particular arrangement of matter and energy. The arrangement, indeed, is very similar to that which prevails in, and constitutes, a healthy organism; but here and there the matter and energy are somewhat differently located, so as to constitute what is called a tuberculous organism.

Before infection, the matter and energy of the organism were normally distributed. At the moment of infection there is an addition of a minute quantity of other matter and energy specifically distributed into a number of little bodies, which we call bacilli; and their matter and energy, combined with the matter and energy of the healthy organism, undergo further redistribution, resulting ultimately in that new arrangement which is characteristic of the disease. All this works by inevitable laws, just those same laws which control the unceasing redistribution of matter and motion in every part of the Universe. The cause of any phenomenon is found when we have described the antecedent state of distribution of the matter and energy which are combined to constitute that phenomenon.

It happens, however, that in practical life we are commonly interested only in one element out of the numerous constituent parts that go to make up a phenomenon. From the objective point of view this element is very often extremely insignificant, yet we confine the appellation of cause to it alone. In the example above cited, the objective or absolute cause of a tubercular lung is furnished only by an account of the origin or previous state of distribution of the matter and energy constituting the lung, as well as of that constituting the bacilli. But we are in the habit of taking the lung for granted, and referring to the bacilli as the cause of the disease. The reason of this is, that the matter and energy of the healthy lung undergo transformation normally in a uniform and regular manner: the organ undergoes what is called a healthy metabolism. Matter and energy are unceasingly being introduced from without, to take the place of that used up. We are only interested in the breach of that uniformity, and the assumption of a new kind of distribution. Although, therefore, the unceasing supply of abundance of new matter and new energy is as essential to the continued existence of a diseased lung as of a healthy lung, and although this abundance is objectively the predominant factor in the production of a tuberculous lung, yet we do not speak of it as the cause of the tuberculous lung, because we take it for granted, and concentrate our interest on the new and unusual factor. From other points of view, we might take just the same facts, originating in just the same way, and yet assign equally correctly another quite different, though, of course, not conflicting, cause, simply because our interest is differently orientated. Suppose, for instance, that we knew nothing of men or any animals, but were entirely wrapped in the lives and history of bacilli. We may be watching a little colony of bacilli which have, for many of their generations, led an uneventful or somewhat precarious existence, perhaps in milk or dried up in dust, etc. Our attention being fixed exclusively on them, we may be startled to find that the colony suddenly becomes inexplicably prosperous. The bacilli become fat and healthy, they reproduce in enormous numbers, having by chance become transferred to a favourable environment, viz. a susceptible lung. The state of affairs is that which has already been described—a lung swarming with bacilli. What is the cause of this state of affairs? Fixing our interest now on the sudden prosperity of the bacilli, we must assign as a cause the favourable nutritive condition supplied by the lung. From the point of view of the bacilli, that particular distribution of matter and energy which we called a tubercular lung, is due to the continued supply of nutritive material through the blood of the infected organism. To the man, the cause of the phenomenon in question is the supply of bacilli to the lung. To the bacilli, the cause of the phenomenon is the supply of a succulent lung. Both are true and essential causes; yet we only call by the name of cause the particular factor, out of innumerable others, in which we happen to be interested. All the others we name "conditions." In that particular collocation of matter and energy known as a lung swarming with bacilli, the man takes the lung with its metabolic processes for granted, and ascribes the cause of the phenomenon to the invasion of foreign bacilli; the bacilli take themselves for granted, and ascribe the cause of the phenomenon to the food supply constantly furnished to the lung.

The notion of cause has, therefore, both an objective and a subjective element. Objectively, the cause of any phenomenon is the preceding state of distribution of the matter and energy concerned in that phenomenon. From this point of view, it is plain that the efficient cause of the existing state of the Universe at any one moment is its state at the moment immediately preceding. Subjectively, we are interested, however, only in the evolution of some part of the component matter and energy, and we are in the habit of conferring the name of cause only on that particular factor in the evolution that happens to interest us, while designating the other factors conditions.

The above definition of cause at once clears up the problem of the difference between "how" and "why." Many men of science, following Mach and Karl Pearson, have affirmed that science can never explain more than "how" events occur: it can never touch the problem of "why" they occur. On this second point humanity must always rest ignorant. They have thus set up a deep and fundamental distinction between "how" and "why" which a very moderate amount of analysis suffices altogether to dispel. I must ask the reader once more to visualize the Universe as consisting of a fixed sum of matter and energy undergoing redistribution. Consider some momentary and circumscribed phase of that evolution, which in ordinary language is called an event, and let us see how

To answer a "Why" question is merely to satisfy the interest of the Inquirer with some aspect of the

we should answer the two questions "how" and "why" this event comes about. Clearly we describe "how" it comes about, when we render a complete statement of the immediately preceding history of all the matter and energy engaged in it. "How" corresponds to the purely objective definition of cause given above. Now let us ask "why" the event occurs. The answer is given by naming the immediately preceding history, not of all the matter and motion engaged, but of that part of it *in which we happen to be interested.* "Why" corresponds to that final definition of cause, offered above, in which both objective and subjective elements are included. In fact, "why" is simply a limited "how"; it covers less ground; it demands the history, not of the whole of the matter and energy engaged in the event, but only of a particular section of it which happens to arouse special interest.

It follows from the above that, whereas to the question "how" an event takes place there can be but one complete answer, to the question "why" it takes place there may be many answers, and all equally true. For, in order to give a complete answer to "how," we have to describe the preceding history of the entire sum of the matter and energy involved; whereas in order to give a complete answer to "why," we only have to describe the preceding history of one selected element in the sum of matter and motion, and we may choose at random many elements, describing one after another, to satisfy the interest of the inquirer, thus offering a number of true, though different, answers to the same question. To answer the question "how," we must describe all the conditions which led up to the event. To answer the question "why," we name one of these conditions. This one condition, in which special interest happens to be taken, is then called "cause." With a different interest, we should have selected some other of the conditions, and this one would then be referred to as the cause. A few instances will make the matter clear.

Suppose that a locomotive engine linked up to a train is standing at a railway station, and that it suddenly begins to move off. Suppose that the question is asked "why" it has moved. A great variety of answers, all equally true, might be given, and if we did not know the special interest of the inquirer, we should be altogether at a loss how to answer him. We may reply that it moved off because it was timed to go at that hour, or because the guard waved his flag, or because the last passenger had just got in, or because the signal had gone down, or because the engine-driver pulled a lever, or because a sudden pressure within the cylinder had forced forward the piston, or because the friction between the wheels and the lines exceeded the inertia to be overcome, or because some fault in the machinery which had hitherto prevented its moving had at length been remedied. Similarly, when the train stops at the next station, we may analyze the question "why" it stops. We may reply, to enable passengers to get out, or because the engine-driver pulled a lever, etc., etc. And in neither case should we know which of the numerous possible answers to give, unless we were acquainted with the motives of the questioner. Each of these answers names one of the antecedent conditions to the motion of the train, and we cannot know which particular antecedent condition will satisfy the question "why" unless we know something about the purpose with which the questioner is animated. If we had no such knowledge, it would be necessary, to cover all possibilities, to give a recital of the entire sum of antecedent conditions, and these would speedily be found to throw roots far back into the past, and to multiply further the more we followed them, exemplifying the truth that all things in the Universe are bound together by an indissoluble nexus, and that every event is the product, not of one or two single causes, but of the general distribution of matter and energy throughout the Universe at preceding periods of time.

The subject seems so important that I venture to cite one further example. Suppose the question asked is, "Why is the moon full to-night?" a great variety of true answers may be offered, when we are ignorant of the questioner's special interest in the matter. The moon is full because it is placed on the opposite side of the Earth from the Sun; because it has a surface which reflects light; because a month has elapsed since last full moon; because it is a little out of the direct straight line with the Sun and Earth; because the Sun is shining upon that half of its surface turned towards the Earth; because rays of light can traverse space, etc., etc. Our answer to a child would be different from our answer to an astronomer; for the former would be interested in different features of the process from the latter. But in order to furnish a comprehensive answer to the question *how* or by what process the full moon occurs, all these factors one after another would have to be enumerated. The "why" of phenomena is no more than a special case of the "how"; and all questions "why" certain phenomena occur are answered, if at all, only by relating how they occur; nor can they be answered in any other way; nor has the interrogative "why" any other significance that is conceivable to mankind. In explaining why some phenomenon occurs, we merely have to exercise an eclectic discrimination in deciding which of the numerous factors concerned in the process is most likely to satisfy the curiosity of the inquirer. And all those factors, under analysis, may be resolved into a graphical or historical account of the changes undergone from moment to moment by the matter and energy engaged in the production of the phenomenon.

Not only is there no transcendental difference between how and why, as Professor Karl Pearson imagines, but, in the loose and imperfect language of ordinary life, their meanings insensibly grade into one another, and they may even be used indiscriminately. The questions how he got tuberculosis and why he got tuberculosis are very slightly, if at all, different. In other cases the difference is greater, as, for instance, in the questions how he travelled up to London, and why he travelled up to London. The first question would be understood to refer to the more obvious and palpable redistributions of matter concerned in the process, and would be sufficiently answered by replying that he travelled up in a train. The second question, why he travelled, refers to his motive; that is to say, to one special factor antecedent to the process of travelling, a factor to which particular interest attaches.

And this leads me to the second problem which I have here to deal with, the problem of teleology. I have hitherto endeavoured to represent the notion of cause and effect in purely materialistic terms, to the exclusion of all metaphysical transcendentalism; to state the relation of cause and effect in terms of the redistribution of matter and motion. I now have to perform the same task for the conception of purpose, and more particularly of human purpose, in order to show how purposiveness may be translated into purely materialistic and mechanical terms; that is to say, how it, too, may be expressed as a phase of the normal process of redistribution of matter and motion under fixed and invariable laws.

At the outset of this inquiry, we have to notice that the word purpose is involved in the same vagueness of significance that attends almost all words used in popular speech. In general a word in popular use has to be defined and limited to some precise meaning before it is fit for employment in a philosophical discussion. In the present case the word is commonly employed in at least two meanings, which differ greatly from each other; and this duality of meaning leads to a duality in the derivative conceptions of "teleology," "finalism," "end," etc., which has not infrequently given rise to confusion and error. The two significations may be roughly grouped as intelligent purposiveness and unintelligent purposiveness, and the reduction of each of these to mechanistic terms involves two different lines of analysis. I shall deal first with unintelligent purposiveness.

In this case, the word is usually applied to a certain kind of organic reactions that bear an obvious relation to the requirements of the reacting organism. An *Amœba* in the water throws out pseudopodia at random in all directions. When one of these pseudopodia comes into contact with some substance suitable for food, the protoplasm streams round and encloses the particle, which is thus incorporated in the body of the *Amœba* and there digested. The reaction is purposive in the sense that a somewhat complicated series of movements is carried out, which leads to the preservation of the active organism.

In just the same way, when we ascend the animal scale, the sea-anemone spreads its tentacles at large under the surface of the water. On contact with any substance suitable for food the tentacles contract around the substance and draw it into the interior of the sea-anemone. This action is similarly purposive in that it procures the continued existence of the animal. In all animals the common movements and reactions are predominantly of this purposive type. If an object suddenly appears close to our eyes, we involuntarily close them for an instant, and this reaction is obviously purposive, as directed towards the protection of the eyes.

All these instinctive actions are purposive in character, yet equally, without doubt, they are all of the nature of reflex action, working blindly and inevitably to their conclusion. On contact with the tentacle of a sea-anemone, the stimulus thus applied to that tentacle sets up by entirely mechanical procedure organic processes which necessarily result in the observed contractions. Similarly, in the case of the human being, the sudden appearance of a near object causes an impulse to be conveyed down the optic nerve, which immediately and mechanically propagates its effect to the efferent nerves which lead to the muscles that close the eyelids. The same kind of reaction is characteristic of the functions in plants. The turning of flowers towards the light, and all the processes of absorption, transpiration, etc., are, on the one hand, subservient to the life and prosperity of the plant, while, on the other hand, they are blind mechanical reactions to stimuli.

Seeing that a single action may thus be at the same time both purposive and mechanical, it is plain that there can be no antithesis between the two; but that the difference between purpose and blind mechanism arises simply from our point of view, and not from any difference of objective character. Purposive reactions are not different from mechanical reactions, but they *are* mechanical reactions of a certain kind. Not all mechanical reactions are purposive, but all purposive reactions are mechanical; and it remains to determine *what* mechanical actions may be correctly described as purposive, and what are simply blind and meaningless.

The distinction is entirely one of convention. I have represented all events in the light of a redistribution of matter and energy under fixed mechanical laws. Certain particular phases in this redistribution, certain particular collocations of the evolving matter and energy, happen to possess for us a very special interest, and we watch with peculiar attention the material developments and antecedents which give rise to those particular collocations that concern us. Of such collocations, the most enthralling is the maintenance of that moving equilibrium which we call the life of an organism. This equilibrium is due to a succession of stimuli from without, met by "adapted" reactions on the part of the organism; and it is to that particular item of the universal mechanism called an adapted organic reaction, that we apply the name of purpose.

The material origin of all purposive reactions would be adequately explained by the theory of Natural Selection. We must suppose that, at the origin of life, the primeval little speck of organic matter would respond in any haphazard kind of way to the stimuli affecting it from without. These organisms or pre-organisms would in every case give a blind response, due to the chemical or material constitution of their protoplasm. By the ordinary laws of chance, the vast majority of these reactions would not be such as to promote the continuance of life, and in many cases would be such as immediately to destroy life. But again, by the ordinary laws of chance, it would happen in some cases that the response to external stimuli would be such as in some way or other to favour the continuance of life. Pre-organisms, the chemical constitution of whose protoplasm was of this type, would flourish and be perpetuated, while all other types of incipient life would be extinguished. The reactions of the surviving pre-organisms are what we should call "purposive." In this sense, therefore, we mean by purpose those reactions of organic matter which happen to promote the continued existence of that organic matter. By the mechanical process of Natural Selection, all varieties of organic matter that respond unpurposively—that is, whose responses do not happen to promote their continued existence—perish, with the result that either the whole or the larger part of every animal's activities are purposive in character. At first, therefore, Natural Selection is the great teleological agent. The net result of this analysis is that purpose is a name given to certain material phenomena which fulfil some arbitrarily chosen condition, and withheld from all other material phenomena which do not fulfil that condition. The condition usually taken in simple cases is the maintenance of life, and among the factors in this maintenance of life are commonly selected those which involve organic activity. All such organic activity is then said to be purposive.

The point specially to be noticed is that purpose is purely arbitrary and subjective; it corresponds to nothing in outer nature, nor are purposive acts in any way objectively different from random acts. By selecting a new set of conditions to be satisfied, or a new standard, it is possible to represent any kind of mechanical event as being purposive. Supposing, for instance, that the condition to be fulfilled was that the planets of our solar system should revolve round the Sun in the orbits that they actually do; supposing that we had a great personal interest in their doing so, and anxiously watched all material developments in the primeval nebula which appeared to lead to such a consummation; supposing that we can transfer ourselves to this cosmic point of view, we might then rightly affirm that gravitation is purposive, just as we now affirm that Natural Selection is purposive. The one leads to the moving equilibrium of the solar system, the other leads to the moving equilibrium of a living organism. Extinguish gravitation, so that the planets move at hazard, and the solar system will not survive. Extinguish Natural Selection, so that organisms react at hazard, and those organisms will not survive. The parallel is complete; and there is no more *a priori* objection to calling the movements of the planets purposive than there is to calling the movements of animals purposive. The former are "adapted" to the continued maintenance of the solar system, the latter to the continued maintenance of vital manifestations. If we do not call the cosmic manifestations purposive, but do call vital manifestations purposive, it is because we are intensely interested in the latter, and but slightly interested in the former. The continuance of life, the satisfaction of needs, etc., are conditions that appear to us so important as to demand a special name for the most prominent group of factors concerned in them; whereas the continuance of the solar system, and the unfailing adherence of the planets to their present orbits, is not a subject of such overweening importance, or of such unceasing allusion in common life, as to require the establishment of a special name. A purposive movement, therefore, is an ordinary case of the redistribution of matter and energy. The name is used in those cases where the matter and energy are knotted up into that structure which we call a living organism, and is applied to such activities of the organism as conduce to its own continued existence.

I now come to the second class of activities to which the name of purpose is applied, that is to say, cases of activity which bear reference to an end consciously and intelligently foreseen, such as the acts inspired by the conscious will in human beings. These activities are commonly regarded as being in a higher degree teleological than the unintelligent reactions hitherto considered; and in many uses of the word "purpose," reference is intended exclusively to these intelligent anticipations of future events, and to the activities carried out in consequence of such anticipations. In this sense purpose is allied to will, and purposive actions are more or less synonymous with voluntary actions. The question before us, therefore, is whether the will can be comprised in the materialistic scheme which governs all other natural phenomena, or whether it is something outside and independent, knowing no laws, and therefore not amenable to scientific discussion. And this question, again, is nothing more than the problem of free-will and determinism; of vitalism and mechanism; of spiritualism and materialism; according to the standpoint from which we approach it.

The exclusion of the will from materialistic laws is refuted by considerations of every kind, and refuted with equal facility from many different points of view: from biology, from physiology, from psychology, and even from logic alone. Any one of these sciences can furnish overwhelming refutation of the hypothesis of the independence of the will, a hypothesis which never could have obtained any attention from philosophers were it not that it harmonizes so well with the ignorant prejudices and superstitions of the multitude, and thus, being refuted time after time, was constantly pressed anew on their attention.

We noted in Chapter IV that there is no qualitative difference between the simpler reflex action and the highest or most complicated reactions that the developed nervous system is capable of evincing. In the lowest animals, the nervous system is adapted simply for conveying impulses from the outer surface to some nerve-centre, whence proceeds a new impulse along another nerve back to the periphery, causing a contraction or some other movement. The whole procedure is purely mechanical. Now the most developed known nervous system arises by evolution in gradual stages from this most elementary form, and the mode of development consists in the compounding of reflex action. From the simple reflex-arc arise multitudinous other reflex-arcs, integrated together into one great nervous system. Instead of one nerve running from periphery to centre, many nerves run; a corresponding multiplication occurs in the outgoing nerves. The centre likewise increases beyond recognition in elaboration and complexity. It is broken up into a number of constituent parts, themselves connected by bundles of nerve-fibres, and higher centres grow up, which receive impulses from the lower centres, and send back others. But the simple reflex-arc remains the unit of functional activity and of structural form. However infinite the complication of the developed system, it is still based on the simple reflex-arc, and, indeed, consists of innumerable reflex-arcs compounded together in every variety. The reflex-arc is mechanical in function; hence the developed nervous system is mechanical in function. Nowhere is there any break in development, at which we might suppose that a new and non-mechanical factor makes its appearance.

The relation between the highly compounded nervous system of a man to the elementary reflex-arc corresponds to the relation between the intelligent purposiveness now under discussion and the unintelligent purposiveness analyzed above. We now have to consider which of the reactions of the nervous system are to be called purposive, and which are to be looked upon as merely random.

One of the most striking features of the developed nervous system as compared with the primitive system is that a stimulus does not give immediate rise to an action. In the elementary animal, stimulus is promptly followed by contraction. In the highly developed animal, the stimulus may simply take effect on the nervous system without causing any external response. The nervous system, however, is to some degree affected by the stimulus, so that at future times different actions will arise from it from those that would have arisen if no such stimulus had ever been experienced. So, too, the nervous system may initiate an action without any immediately preceding external stimulus. Instead of the primitive arrangement by which a stimulus elicits a simple and immediate response, a stimulus may now impinge upon the nervous system and leave its effects stored up there. It buries itself, and is lost in the complex maze of nervous tissue; in so doing it causes some modification of that tissue, which will thereafter affect the responses to stimuli upon it. The sequence of stimulus and response is obscured. In a highly developed nervous system, the stimuli incessantly entering no longer bear any immediate relation with the responses incessantly given out. The brain provides a great storehouse and clearing-ground for nervous impulses, so that the impressions entering and the impulses departing from it lose a great part of their immediate connection. The incoming currents spend themselves in effecting some rearrangement of the matter and energy belonging to the brain. Outgoing currents are similarly due in very many cases to rearrangements occurring in the brain, the product of a number of elements internal and external, rather than to any individual external stimulus. To this is due what appears to an outside observer as the initiating power of the brain, and all those kind of activities known to psychologists as choice, will, etc.

We are now in a position to appreciate the true meaning of those acts which are described as intelligently purposive. Being deliberate and reasoned activities, they are as far as possible removed from the simple type of reflex action in which response follows immediately on external stimulus. They belong to the category in which the immediate stimulus is in the brain itself, and is to be regarded as consisting of rearrangements of the matter and energy contained in the nervous substance of the brain. The brain during consciousness can never be still, and its unceasing activities supply the stimulus, not only for purposive, but for all actions of an intellectual character. Now this permanent cerebral activity can be divided into a number of different types, known psychologically by such names as memory, imagination, reason, etc. Although nervous physiology has not yet advanced far enough to enable us to say what are the different kinds of material processes in the brain corresponding to these psychical processes, yet there is no doubt that the psychical distinction is based upon some actual distinction in the corresponding activities occurring in the brain. Among these cerebral processes is that which is known psychologically as a desire for some external object or event, a visualization of some external phenomenon as an end or purpose to be attained. This desire may then act upon efferent nerves and give rise to the activities which we know as purposive. The essence of a purposive action, and the standard by which it is distinguished from other kinds of actions, is that the "end" to which the action leads was previously represented in the brain of the agent, and composes the stimulus of action. The compound stimulus arises, as I have said, from the composition of large numbers of elementary stimuli previously received. It consists psychologically of a faint representation of the sensation which would be vividly presented by the realization of some outward occurrence. And when this faint representation actually functions as a stimulus which innervates the muscles whose contraction brings about the external occurrence represented, we have what is called an action of intelligent purpose.

Hereafter the analysis is identical with that employed in the description of unintelligent purpose. The only difference is that the stimulus which in the latter case consisted of a simple external contact, is replaced by a complex cerebral pattern, based upon, and produced by, a large number of these stimuli acquired at various former periods, and of course determined by the structure of the brain. It may be asked by what process it happens that a faint psychical (or cerebral) representation of some desired sensation can give rise to just that complicated series of muscular activities needed for the actual realization of this sensation. The answer is the same as in the case of unintelligent purpose, when we inquired how the stimulus provided by contact of a food-particle set up just the right contractions for absorbing that particle into the substance of the organism. The answer suggested was *Natural Selection.* In all cases where the complex cerebral stimulus causes a muscular activity that does not happen to meet the end in view, the organism is extinguished. Only that small minority survive in which the correct muscular activity is brought about. A new factor is indeed introduced, owing to the circumstance that the brain is functionally (and therefore in some way histologically) excessively pliable, and owes more of its ultimate development to education and environmental influences than is the case with the nervous apparatus of inferior organisms. To this extent Natural Selection is replaced by a less rigid discipline. Error need not result in extinction, but merely in pain or in privation of the end desired. This pain or privation constitutes a new stimulus, which combines with the many other elements in the previous cerebral pattern, and suffices to intermit further muscular activity of the kind which has been injurious. In proportion as the animal's educability is developed, the rigorous consequences of Natural Selection are mitigated. The old process of trial and error continues, but it is no longer a process of immediate life and death. Education itself, or the information gained from the knowledge and experience of others, largely contributes the elements of that complex cerebral pattern which acts as the stimulus to purposive activities.

Intelligent purpose, like unintelligent purpose, is then only a name given to a particular kind of incident in the midst of the eternal redistribution of matter and motion under blind mechanical laws. It is in perfect harmony with that materialistic scheme; it can be stated in terms of the purest mechanism. As the matter and motion undergo their invariable and unalterable redistribution, we naturally find ourselves more interested in some phases of it than in others; and in one class of evolving events we are so interested and we have such frequent occasion to refer to them, that we denominate them by a special name—the name of purposive. By this name we designate the majority of those redistributions which issue from the little whirlpools of matter and energy called organisms, and those factors in particular by which the immediate continuance of such whirlpools is ensured.

I have now dealt with the law of universal causation, and with the doctrine of teleology. It remains only to say a few preliminary words about the third main pillar of materialism—the assertion of monism, that is, that there are not two kinds of fundamental existences, material and spiritual, but one kind only. This doctrine forms the subject of the next chapter. For simplifying the discussion, it will be as well at once to dismiss from consideration all those kinds of spiritual entities imagined by religious believers. The Victorian writers said on this subject nearly all that could be said, and interest now attaches only to those problems of matter and spirit which they left unsolved. I shall, therefore, confine myself to an attempt to reduce the last stronghold of dualism; to ascertain the relation between mind and body; to show that mental manifestations and bodily manifestations are not two different things, as generally supposed, but one and the same thing appearing under different aspects.

I shall not attempt to deal with any of the so-called "non-material" existences with the exception of mind; for if mind can be identified with matter, all other kinds of non-material entities must lapse, even those described by religious systems.

It has often been observed that the progress of knowledge has involved strong tendencies towards monism and away from all kinds of dualism. The early philosophers were fond of establishing fundamental antitheses, such as between wet and dry, hot and cold, light and dark, male and female, etc.[1] Organic and inorganic, animal and plant, were likewise regarded as being in radical opposition. These bi-polar theories have all given way to monistic conceptions in modern science. The same evolution has occurred in our ideas both of energy and of matter. Heat, light, sound, motion, etc., were formerly regarded as being so many independent manifestations; now they are known to be fundamentally the same, and any one kind of energy can, at all events in theory, be transformed into any other kind of energy. So with reference to matter. The chemical elements, formerly regarded as wholly distinct from one another, are now looked upon as being all developed from one common type. It is therefore altogether in accordance with what we should expect from the evolution of knowledge, that the rigid distinction previously drawn between mind and matter should be found untenable, and that these two, apparently opposed, manifestations should be seen to have a common basis. With recognition of this truth, complete continuity and uniformity will be established between all classes of phenomena, and philosophical discussion can only turn on what particular kind of monism we are to accept. The treatment of this subject is postponed to the following chapter.

At present we have shown how the law of causation and how the conception of purpose are essentially materialistic phenomena. The prevailing confusion as regards causation

[1] *History of Biology*, by L. C. Miall, p. 66.

is due to an intrusion of the subjective method into a purely objective problem. There is no transcendental difference between "how" and "why." When we say "why" an event occurs, we are merely describing one element in the total story as to "how" it occurred—that element which for the moment excites our subjective attention. Regarding all processes in the Universe as a redistribution of matter and energy, the *cause* of any event is found by naming the antecedent distribution of the matter and energy involved in that event. In practical life, we usually refer only to one aspect of this total "cause," and we then use the word "cause" in the limited sense suggested by our present interest.

So, also, the difficulty as regards teleology is due to confusion between the subjective and the objective. In the continuous flow of matter and energy, we single out those items which chance to have a special bearing on our own existence, and call them purposive. If interpreted by Natural Selection, they are seen at once to be purely mechanistic. Not that it is *necessary* to invoke Natural Selection for such an explanation; purposive results may be achieved by mechanistic methods other than Natural Selection, and Darwin's theory in the foregoing discussion has merely been used as a convenient illustration of *one* way in which purpose can be rendered in terms of mechanism.

As regards intelligent purpose, as evinced by human beings, the same principle holds good. In this case, some definite desired end is attained by an act of definite will. The chain of material sequences lies mainly in the brain of the agent. The final consummation is preceded by particular cerebral states known as desire and will. All those sequences into which these states enter at some stage are termed intelligently purposive. Sequences into which they do not enter are regarded as mechanical. Yet there is between them no objective difference. The difference is purely subjective, and relative to ourselves. All confusion arises from the old anthropocentric fallacy—the supreme difficulty of taking up a wholly external and objective attitude towards ourselves. Just as the savage supposes the whole Universe to be specially created for the benefit of himself or his tribe; just as the more civilized man supposes the Universe to be specially subservient to the human race; so in the most recondite problems of philosophy our arguments tend to be vitiated by infusion of the subjective element, in such a way that we read into external nature the human interests and egocentric habits which belong to our own minds.

I shall conclude this chapter with a few words as to the scientific method espoused by materialism. It is the method of observation and experiment, and these two are in reality the same. An experiment is only an observation under artificial conditions. When we observe some manifestation occurring under natural conditions, our method is that of observation; when, on the other hand, we observe some manifestation occurring under conditions that we have ourselves purposely established, our method is that of experiment. The advantage of experiment over simple observation is partly that we can produce the required phenomenon at a time and place convenient to ourselves, and partly that we have a more exact knowledge of the conditions under which it occurs. Experiment is a process of analysis. We select certain conditions, and exclude certain other conditions, and we then see what happens. If we were debarred from experiment we should be debarred from analysis, and often compelled to wait long periods before Nature furnished us with an example of the particular phenomenon we desired to witness.

Admitting that observation and experiment are two varieties of the same thing, we find at least two rival methods in very frequent use. The one is that of innate knowledge. It is held by some that knowledge of detailed and complicated phenomena is implanted within us by Nature or God, wholly independent of experience acquired by observation, experiment, or education. Such is the opinion of those who set up "faith" against science. Such again is the opinion of philosophers like Bergson, who rank instinct as a rival method to intellect for the acquisition of knowledge. I have already dealt with this superstition in a previous work, and shall say no more about a doctrine so utterly at variance with the tone both of science and materialism.

A more serious rival to the methods of observation and experiment is the deductive method. It is more serious, because it is a genuine and true method. It is often not only a reliable, but an absolutely certain method of discovering truth, and the only method by which such truth could ever be discovered. It is therefore infinitely different from the spurious method of instinct, which is always and invariably false. It is just the very power of the deductive method, under certain conditions, that constitutes it so dangerous an adversary of observation and experiment. For it is universally applied in wider spheres than that to which it is appropriate. In mathematics, and in a large part of physics, the deductive method is paramount. In geology, biology, and physiology, which are still in the inductive stage, any kind of deduction has to be employed with the greatest caution and circumspection, and this necessity arises from the fact that in these inductive sciences the phenomena observed are commonly due to the interaction of a very large number of separate factors. Now deduction can only deal with phenomena in which the causative factors are very few and simple, as is the case in mathematics. I will take an example from political controversy.

Socialists affirm that slum-dwellers, badly housed and fed, undergo some physical deterioration as a result, and that this deterioration being inherited by their children, of whom they produce a large number, involves a deterioration of the race. This deduction is rather conspicuously false. In the first place, assuming that slum-dwellers do become physically degenerate, there is no evidence whatever that such degeneration is inherited by their children. On the contrary, the great preponderance of biological opinion is opposed to any such view. In the next place, supposing that the degeneration were inherited, there is still no evidence that any racial degradation would result. The process might simply be one of a wholesome extinction of weak stocks. I do not know whether this is so or not: all that I do know is that the deductive method is applied in their argument several times over where it is inapplicable, and, in consequence, that the conclusion reached has no relation to the truth, one way or the other. It is affirmed, on the other hand, that nations which have lived in slums for many centuries have not in consequence degenerated, and this *observation*, if correct, is of more value than a whole multitude of convergent deductions.

But the anti-socialist arguments are equally deductive; and it is for this reason that so much of Herbert Spencer's social writings are worthless. He argued that if the whole nation is taxed to subsidize the poorer sections of the people, ruin must result; for, in general, the poor are the feeblest part of the community. You are therefore taking money from the strong to give to the weak; you are making it more difficult for the strong to survive, and easier for the weak to survive. Ensuing generations will, therefore, be weaker than the present. Furthermore, by giving money or goods to those who have little of either, you discourage providence, and national impoverishment will result.

Now here we have a string of deductions in a sphere where deduction is altogether unreliable. There are in all probability a large number of factors involved in the causation of racial degeneracy, as of national impoverishment. Spencer isolates one or two such factors on which his attention happens to be directed, and forgets the possibility, or indeed the certainty, that the results of these few factors will be altogether drowned amidst the rest. When compulsory national insurance was instituted in England, it was prophesied that the sale of patent medicines would be largely diminished; for when the people can get their medicines free, it seems obvious that they will not continue to purchase expensive drugs, which are in every respect inferior to those they can have for nothing. This deduction seemed so obvious that the Chancellor of the Exchequer budgeted for a large falling-off of revenue on patent-medicine stamps. Yet, when the Act came into force, a very remarkable increase occurred in the sale of patent medicines. A deduction which seemed at the time to be absolutely certain and necessary, was completely falsified by the facts.

Instances of misapplied deduction might be multiplied *ad infinitum;* the whole world of politics is riddled with it. For the present, I have only to note that a tendency exists to use deduction with far too much freedom in biology and all its allied and derivative sciences.

On the other hand, deduction cannot be dispensed with, even in these sciences. Take the following proposition, which is exclusively empirical in character. All white male cats that have blue eyes are deaf. The proposition is interesting, but of very limited value to science unless it is linked up with other known facts of biology. Standing alone, it teaches little. We are at once met by the question, why are they deaf? And to answer this we are driven to resort to a moderate degree of deduction and generalization, by means of which an answer may perhaps be attained without serious danger of error. Without deduction biology would be nothing; and perhaps the most fundamental difference between the trained biologist and the raw student is that the former knows by experience when he may safely use deduction, and the latter does not. But even the best biologist must often make mistakes, and a vast acquaintance with details is often a less useful possession than a mind of philosophical amplitude backed by a sufficient though smaller acquaintance with details. The specialist Cuvier formed a less accurate idea of species than the philosopher Goethe.

The whole subject, in short, is extremely difficult; and the difficulty of understanding the correct use of deduction is accountable for the fact that the biological sciences are broken up into so many diverse schools of thought, among whom no agreement can be attained. It is probably impracticable to make any suggestions for rules on this abstruse subject. My purpose here is merely to indicate that the general reader and non-specialist scholar is certain to use deduction with excessive frequency, unless very carefully warned in advance. All the emphasis must be laid, therefore, on observation and experiment. The Baconian method is nearly always laborious, expensive, and difficult; it is very often utterly impossible of application; yet it is the only method by which truth can be safely sought. Deduction, which can be carried out by a few minutes' thought in an arm-chair, is easy and cheap; hence the overwhelming tendency to employ it. In science and philosophy no solution that has been reached with little trouble is likely to be of the slightest value, and most of the things we really want to know are not ascertainable by any degree of effort whatever.

It remains only to indicate the heuristic value of the doctrine of materialism. To many it may seem useless to formulate a philosophy of this or any other kind. Nevertheless, such philosophies provide a general outlook or point of view on scientific problems which is in the highest degree valuable and fertile for future progress. We learn from a sound materialistic philosophy, not mere individual facts, but the *kind of way* in which Nature hangs together. When we are confronted with a new scientific problem, our philosophy may tell us at once that the solution is along certain lines of investigation, and it may expressly exclude other lines of investigation. We shall investigate alleged instances of telepathy without the slightest reference to any of the silly popular theories on the subject. We shall study problems of conduct and of thought from the point of view of physico-chemical mechanism, and shall not improbably reach conclusions of great importance, that we never could have reached without such general outlook. In morals and politics we shall understand the motives of mankind, which to others must remain for ever sealed. Infinite capacity of doing good necessarily follows, if we happen to be philanthropically minded. Materialism, in short, acts as a general guide and starting-point for investigation, which must furnish its possessor with unusual powers, whether in research or in action.

I regard the establishment of a materialistic philosophy, therefore, as a consummation of the highest utility, partly on the ground of the destruction of superstition, but still more on the ground that it inculcates a particular mental orientation which is productive of a powerful impetus towards scientific progress. It involves a sound general outlook on Nature, the suppression of falsity, and the triumph of a true method.

To those, however, whose inclinations dispose them to deny the utility of so unpopular a philosophy, I reply on still higher grounds. I reply that it does not matter whether this philosophy is useful or not. Truth is an ideal which is worthy to be pursued for its own sake, without reference to its utility. Philosophers and men of science are not like merchants and tradesmen, who deal in commodities on account of their utility or of some popular demand for such commodities. Our purpose is different from that of the tradesman. The goods we supply need have no practical utility whatever; and so far from being adapted to a popular demand, we continue to turn out our goods even in spite of extreme popular dislike. We deal in truth, and not in values. Doubtless, many of the greatest utilities have sprung from apparently the most transcendental investigations. Doubtless it is true that the highest stages of civilization have invariably been characterized by studies and speculations that are as far as possible removed from every consideration of utility. We do not seek to justify our course by any such considerations; nor is it worth our while to take up the easy task of proving that the happiness and progress of humanity have depended far more on the transcendental researches of the savant than on the humble utilitarianism of the tradesman. It is enough for us to have before us the great ideal of truth, and to know that, even though we may be mistaken, we have done our best towards the enlightenment. Our motto was given us by Pasteur—"Travaillons." Let us continue to work without consciousness of any ulterior end; let us continue to pursue our labours after knowledge, to whatever unknown goal they may lead us.

CHAPTER VI

IDEALISM

We at length reach the final stage in presenting the philosophy of Scientific Materialism. The preceding chapters have shown that no intelligible explanation of events can be given from any standpoint except of a materialistic nature. There is no place for "spirit" in the subject-matter dealt with by astronomers or by physicists. Biology is equally founded on a basis of pure materialism. In physiology the theory of vitalism which imagines a spiritual intervention in physiological processes is hopelessly discredited, and has now been abandoned by all physiologists in practice and by the great majority also in theory. We are led, therefore, inevitably to the conclusion that the causation of events of every kind is purely materialistic. We have not yet in the course of our studies come across any kind of causation that is spiritual in character, as opposed to physical. The Universe is governed by the physical laws of matter, even to the most refined and complex processes of the human mind.

Are we to infer from this that materialism is the only true philosophy? Such an inference is not justified by any evidence we have yet considered. The only inference we are entitled at present to draw is that materialism is the basis of natural science. Science necessarily assumes materialism for its foundation; it rests upon materialism as chemistry rests upon the atomic theory. But just as chemists long looked upon the atomic theory simply as a good working hypothesis, without committing themselves to a belief in its absolute truth, so we are now in the position of recognizing materialism as a good, and the only good, working hypothesis, without having yet investigated the question of its absolute truth. Whether any solution is possible to such a question, and if so what solution, is the subject to which we have now to address ourselves.

To the ordinary educated adult, the first and so-called common-sense view seems to disclose two utterly dissimilar kinds of existence, known respectively as mind and matter. And, in consequence, so-called common-sense philosophers, such as Herbert Spencer, have affirmed that the difference between mind and matter is greater than any other differences that come within the range of our consciousness. Everybody thus starts studying philosophy as a dualist, and many of the problems of philosophy arise out of the question as to the relationship between these two alleged dissimilar existences.

But why are we thus to start from the pre-formed impressions of the adult? In doing so we come to the study of philosophy in its middle: we already bring with us to the subject a dualistic conclusion which should be, if it is true, at the end and not at the beginning of a philosophical inquiry. I propose, therefore, to commence this study, not from the experiences of the educated adult, but from the experiences, as far as they can be ascertained, of a newly-born infant, whence I shall trace them to the more developed outlook of the adult.

We at once observe that the baby's experiences are not such as to yield a theory of dualism, but a theory of monism. The baby does not have two utterly dissimilar types of experiences; it has only one; and that one takes the form of a succession of sensations of varying intensity and kind. It possesses no instinctive knowledge of matter or of distance. The impression derived from the eyes is merely that of a disordered mixture of colours and shades. The visual impression which gives rise in an adult to the conception of a table, is to a baby no more than a congeries of colours, of differing brightness or darkness. It conveys no idea of solidity, or hardness, or distance, or any other material attribute.

The sense of touch, in the same way, yields nothing more than a series of isolated sensations. The prick of a pin is known only as a sensation. It is not referred to any outer world; it is not associated with the idea of matter; it is not recognized in any way: it is merely a sensation, meaningless and unlocalized.

The emotions belong to the same category. They are mere units in the succession of sensations, differing perhaps by their greater intensity, but meaning nothing. The baby, moreover, is not only completely ignorant of any external world, it is completely ignorant of its own body. In short, the entire experience of a baby is psychical in character. It knows nothing of matter; and if it were endowed with the power to form philosophical theories, it would never divide up the Universe into mind and matter. It would be cognizant only of one order of existences—that which adults describe as psychical.

The next step in our inquiry is to ascertain how the conception of matter first arises, and this, fortunately, is a question on which the facts are pretty clear.

Sensations soon cease to be isolated units and enter into associations with one another. A particular visual sensation is accompanied on frequent occasions by particular tactual sensations. A visual sensation of brown colour is associated with tactual and muscular sensations of hardness, resistance, smoothness, and so on. Tactual sensations in general become universally associated with visual sensations; and special tactual sensations such as pricks become associated with special visual sensations, such as the appearances of sharp points. In short, a certain order begins to appear out of the hotch-potch of disconnected sensations. They are no longer perfectly liquid, appearing and disappearing at hazard; they begin to clot. The arrival in consciousness of one sensation begins with some regularity to be the sign of other coming sensations. The sensations become combined or associated into groups, and, as time goes on, the groups become larger. One sensation does not suggest one other merely, but several others. These little associated groups of sensations must appear first as islands in the midst of the primitive sensational ocean. They appear, of course, long before any power of speech is acquired; but they, nevertheless, are the foundation of what adults call "matter." We may suppose that the conception of matter originates with the association of certain colour sensations with the sensation of resistance. Other sensations are soon added; and the individual sensations which compose the group are what adults term the "properties of matter."

One of these properties, which is by no means among the earliest to appear, is that of occupying space. A very young child is hopelessly at sea in its attempts to estimate the distances of objects; even objects close at hand are miscalculated, and remote objects present insuperable difficulty. A child will reach for the moon when it is already many months old. The reason for this is that the cluster of sensations which give rise to the idea of distance is somewhat complex. There are, firstly, the lights and shades of the object itself, the brilliancy or dullness of its colours; there is, secondly, the sensation which accompanies particular degrees of convergence of the optical axes; there is, thirdly, the sensation characteristic of the contraction of the muscles which regulate the amount of the convexity of the lenses in the two eyes; and there are others less important.[1] All these have to be associated with one another and with the sensation of the muscular effort required to reach the object, before any idea of distance or solidity can be obtained. To an adult, a flat object like a drawing may be made to look solid by artificial production of one of the sensations which enter

[1] The great importance of muscular adjustment of the eyes in the perception of space and of matter suggests a biological explanation of the fact that out of the twelve cranial nerves, no fewer than three have an oculo-motor function.

into the conception of solidity, as happens with the stereoscope. Thus we find that the earliest events in a child's mental life are the coalescence into groups of some of the previously isolated elements of consciousness. The sensational sea, from being entirely liquid, begins to solidify. The sensations no longer move among themselves with perfect freedom and disorder; many of them have become coherent; they have solidified, and begin to be recognized as matter.

With increasing "knowledge" the little clusters of sensations continually swell; new properties of matter are "discovered"; until at length we reach the learning of the physicist, whose conception of matter is associated with an infinitely greater diversity of properties than is dreamt of by the child. In the infant's mind, matter has at first, perhaps, only two properties, colour and resistance. Only two sensations are loosely combined together. In the physicist's mind, the properties of matter are numberless. It is divided up into molecules and atoms, too small by a millionfold to be perceived by any microscope, and these are divided up again into particles still smaller. That is to say, the number of sensations, or possible sensations, bound together in the physicist's mind under the title of matter show little trace of the humble origin from which they started to evolve.

We thus reach a justification to some extent of philosophical idealism. Idealism insists upon the fact that the entire knowledge and experience of adults is purely psychical, just as is undoubtedly the case with the baby. The adult's knowledge of matter, like that of the baby, is gained only through sense-impressions, and the perceptions and inferences drawn from them. And there is no great alteration in the quantity or variety of the impressions which affect him. His more advanced nervous organization may allow him to see a greater variety of colours, to hear a greater variety of sounds, or to feel a greater variety of tactual impressions. But the advance in mental organization is altogether out of proportion to the increase in number of the mere units of consciousness. It depends upon the fact that those units now bear a meaning; they are no longer kaleidoscopic and ephemeral as they were. A particular set of visual sensations may now give rise to the knowledge of the presence of a table. Those sensations are not mere colour-sensations, which tell nothing, as in the baby's case. They suggest a portion of matter, of a certain distance, a certain size, shape, use, hardness, and innumerable other qualities. The change is analogous to the appearance of a Chinese puzzle before and after it has been solved. Before, the individual pieces are meaningless and occur at random. Afterwards, the same pieces are associated in special ways together, so as to carry a real meaning.

But if we are committed to idealism, it is an idealism very different from what is popularly understood by that doctrine. As before mentioned, the normal adult invariably comes to this problem with the rooted preconception of two fundamentally distinct entities, mind and matter. By idealism he then, of course, necessarily understands a doctrine which denies the existence of matter, or looks upon matter merely as a product of imagination, or asserts the pre-eminence of mind over matter. All this is mere vain talking which arises from a complete misapprehension of the whole subject. Idealism, as I have described it, does not deny the existence or the reality of matter. It simply states what matter is, in terms of consciousness. It defines a portion of matter as a nucleus of associated sensations. Those associated sensations are just as real as the unassociated reservoir from which they sprang. But, replies the sciolist, the things are totally different. Sensations are within us, matter is outside of us and remains when the sensations called up by it have ceased.

Futile though this criticism is, I recognize the inevitableness of its being made. And the only difficulty in making a reply is, as I hope some of my readers will already perceive, the difficulty of lucid exposition. I have to contend with that profound, deep-rooted prepossession of the duality of mind and matter; a prepossession which has obsessed us during the whole of our lives, which has moulded the very language in which the philosopher has to write. There is no inherent difficulty in the subject itself; but the difficulty of lucid exposition, the difficulty of conveying one's meaning, when almost every word available carries connotations one does not intend, is almost insuperable.[1]

To revert, however, to the criticism before me: matter is outside us and permanent, sensation is inside us and fleeting; how, then, can the two be identified? I reply by asking what is meant by outside and inside. They are but sensations, of the same order as any other kind of sensation. I have already named a few of the sensations which go to make up the notion of distance. Those which compose the notion of outsideness are similar in character. The notion of insideness is composed of certain other types of sensation. Just as matter is a clot of sensation, so matter, regarded particularly as being outside of us, is that same clot with certain of its component sensations holding attention for the moment. Then, continues the idealist, do you assert that the exteriority of matter is a fancy, and that it exists really within us? Not in the least. For the notion of being within is just as much a sensation as the notion of being without. When we get down to bedrock, and are dealing only with sensations as the units of consciousness, there is no such thing as "without" or "within." These themselves are sensations like the others. If the sensations of visual accommodation, etc., enter into an associated clot, then we affirm that the object is without us. If those sensations are not included, but certain others are, then we affirm that the experience is within us. In short, matter with all its properties, spatial and other, can be analyzed into a group of

[1] In the same way, William James writes of his Radical Empiricism: "It presents so many points of difference, both from the common sense and from the idealism that have made our philosophic language, that it is almost as difficult to state as it is to think it out clearly."—*Essays in Radical Empiricism*, p. 90.

sensations, isolated and lawless in the baby, but conjoined into a close group in the adult.

We begin now to see the futility of many of the problems which have for so long vexed and puzzled the metaphysicians. To begin with, there is the absurd distinction between noumena and phenomena; there is the confused idea of things existing "in themselves" as apart from the way in which they appear to us. But to the kind of idealistic monism which I have sketched out, analysis brings down everything at bottom to sensation. There is no meaning in the question whether anything is "behind" matter. Matter is merely a clot of sensations, and the question then has to be put, Is there anything behind sensation? The question is futile, but it is also meaningless. For sensation is the beginning and the end of all knowledge. The idea of something else being behind it or causing it, is simply a sensation itself, and no more. Sensation is the only reality we have to contend with, and to ask whether there is anything else behind it more real, is as reasonable as to ask whether there is anything more alphabetical than the alphabet. Sensations then are real, in the only meaning that that word can ever have for us; and since sensations are real, matter is also real. The hard, solid table on which I am writing is just as real as the sensations of strain and attention with which I write.

Many further questions now arise into view, and must be dealt with in the light of the foregoing theory. One of the most important is to trace the origin of the supposed duality of mind and matter; the relation of mind to brain; the idea of personality; the fallacy of solipsism; and finally the interpretation of materialism and its significance for science and the progress of knowledge. I shall begin first with the origin of the idea of personality. A common criticism brought against idealism is that it commits us to the doctrine of solipsism, that is to say, the belief that I, the *ego*, am the only real existence, and that other personalities are merely figments of imagination. For, says the critic, you say that all matter, and hence too all human beings, are nothing more than modes of your associated sensations, and that is tantamount to the assertion that they have not an existence of the same kind of reality as you yourself with your sensations. The criticism, like all other criticisms on idealism, arises from a misapprehension of the doctrine attacked; a misapprehension which in this particular criticism is repeated several times over. In the first place, the idea of I, or ego, is foreign to idealism as I have defined it; it is as much a product of inference as the idea of you or any other personality. It cannot be repeated too often that we started this argument by taking isolated sensations as our sole data, and association between them as the sole change which could occur among them. Here and there these sensations clot and solidify into material objects. Among these clots there are many which represent, or which are called, men and women; there is one, with specially ramified associations, called *I*. The grounds for believing in the real existence of other personalities are, therefore, co-ordinate with the grounds for believing in the real existence of our own personality. Indeed, in the course of development, belief or knowledge of other personalities comes first. The infant knows its mother as a person before it knows itself as a person; and for some time afterwards it takes an objective view of itself, calling itself, not *I*, but by its name; even offering a biscuit to its foot, and so on.

Still the critic demurs. You have got over the difficulty, he says, of attributing to the reality of my existence a validity less than that of your own; you have explained that you do not regard me as *your* sensation, but you still regard me as sensation. When you die, that sensation will cease. Will it follow, then, that I also shall cease to exist?

The fallacy embodied in this particular question turns upon the meaning of the word exist. Let us transcribe its meaning in our idealistic language. Here is a certain material object; here, that is to say, is a certain sensational clot. Burn the object, and it exists no more. Then among the sensational sequence, that particular grouping will no more be experienced. But this is not yet the end of the matter. It is many years since I was last in Cape Town. The particular clot of sensations which I call Cape Town never enters into my sensational sequence at the present time. Do I then infer that Cape Town no longer exists? Not in the least; for although those particular Cape Town sensations do not at present occur, they are in association with other sensations which lead to the conviction that the sensational sequence might hereafter turn in such a direction as to bring about their repetition. In the case of the burnt object, on the other hand, the associations indicate that, however the sensational sequence may hereafter flow, that particular clot will never again form any part of it. Existence then is not a primordial datum of consciousness; it is the name given to a certain type of association subsisting among sensations. Now to revert to the critic's question. You define me as a clot of sensation. When you die, the sensation will cease. Shall I therefore also cease?

The answer is in the negative. You will no more cease to exist when I die, than Cape Town ceases to exist when I am in London. It is true that when I die the sensational current will cease running; but the associations of your clot are such as to convince me that if by some miracle the flow were to be resumed, that clot would again, if the flow was in that direction, be capable of entering once more into experience. The question of real existence does not depend on whether the sensational flow runs in this or that direction. It depends only on whether, *if* it ran in the right direction, it would experience the clot in question. If I died, my sensational flow would not run in your direction any more—indeed it would not run at all—but *if it did run* in your direction, it would again perceive you.

Still the critic is dissatisfied. You say I am sensation;

you say the sensation may vanish, and yet I continue to exist. How is that possible?

Again I must lay stress on what is meant by "existence." It is simply a certain type of relation or association among the sensations composing a clot. When I say this object exists, or you exist, what I mean is, that the group of sensations composing the object or composing you is associated with certain sensations which we call the idea of existence. If the object ceases to exist, the sensations composing it become dissociated from the idea of existence; there is a break-up in the associations. It is not merely that the object no longer appears in consciousness, for that, as I have said, is characteristic of many objects which do exist: it is that various associations of the object with the notion of existence are broken up, and new associations formed with the notion of non-existence or destruction. Now you ask, when my conscious flow ceases, do you, the critic, cease to exist? And the reply is that you do not, because there has been no break-up of the associations holding you in the sensational sequence. "Your existence" is a phrase naming a certain set of relations existing in the sequence. If you died, those relations would be changed, and I should no longer look upon you as existing. But if you survive, the relations would remain unaltered, even though consciousness did not run in your direction at all, even though it were abruptly to terminate.

This point will be further elucidated by considering the origin of the differentiation between mind and matter. If they are both kinds of sensation—if, as James puts it, they are both made of the same stuff, how comes it that men have always looked upon them as being so widely different? And following upon this question, we have to discuss the origin of ideas of soul, ghost, spirit, and so on.

The main attributes of matter, which distinguish it from mind, appear to be firstly its hardness and resistance to touch or pressure (though this is not characteristic of matter in all its forms), and secondly its occupancy of space. We are unable to think of matter otherwise than as existing in a particular region of space. I have already indicated some of the elements in the associated group of sensations which go to make up our idea of space. A material object, then, is a combination of sensations in which the spatial sensations form one of the component parts. But, as I began by insisting, the primary distinction of matter is in the close and indissoluble association existing between its component qualities; and my present purpose is to show that it is just this indissoluble association which is the sole point of differentiation between matter and mind, between object and subject.

But, I shall be reminded, there is surely a further profound distinction. Matter is permanent, while sensations are ephemeral. Matter is, as Mill defined it, "a permanent possibility of sensation." Mind is a procession of sensations without any permanence at all. This is true, but the case is covered by my definition of matter as closely-associated sensation. I see before me a table. The bald sensations which I experience are simply a visual arrangement of colour and shade. If these visual impressions ended there, and called up no further ideas of any kind, we should say that the experience was subjective. But in point of fact that visual arrangement of colour and shade irresistibly suggests solidity, distance, hardness, resistance, utility, the name "table," and innumerable other qualities. So closely is the visual impression associated with the others, that it is impossible to imagine them dissociated. I cannot imagine that if I walked up to that table and rapped it, I should find no resistance to my knuckles. Yet if it did so turn out, I should promptly set down my visual impression as a mental hallucination. The sole difference between the two experiences, is that in the one the visual impression is associated in experience with other sensations (when it is termed matter), and that in the other it is not associated with other sensations, but is free and unattached (when it is termed mind). The permanency of matter consists in this: that when a sensation arises which recalls a previous sensation associated with a number of others, the new sensation will similarly become associated with those others. To revert to my table. The next time I see it my visual impressions will be such as to recall my present and previous visual impressions. But these are associated with hardness, solidity, and the rest. My next visual impression of the table will therefore be similarly associated with these qualities. It will suggest matter and permanency.

How do such associations come to be established? Supposing the mind to start development from a condition of complete *tabula rasa*, or, as I prefer to put it, suppose the sensations experienced to start in a condition of complete fluidity, each one isolated and disconnected with any other, associated aggregates soon begin to be formed and crystallize out. Visual sensations of a particular kind are so frequently accompanied by tactual sensations of a certain kind, that in future those visual sensations call up a faint form of those tactual sensations of their own accord. A further point to be noticed is that certain types of sensation enter into associative bonds much less easily than certain other types. In general, the intense sensations which are called emotions have little associative capacity. Take the example of a tiger about to spring. The sensations experienced are, in the first place, visual: yellow stripes, snarling jaws, and so on. These suggest irresistibly the idea of solidity and the other material attributes; they suggest the name of tiger; and among other sensations likely to be called up is what we call the emotion of fear. But this by no means necessarily enters the associative group which holds attention at the moment. On the contrary, fear may be completely absent—the attention may be consumed wholly in taking measures to escape from or to kill the animal; or it is even theoretically possible that one may have had enough of life, and welcome the tiger as a convenient way of getting released from it. What I mean is that the emotional element hangs very loosely on to the group of sensations, suggesting a material object. The visual impression necessarily gives the idea of a material object, but does *not* produce an emotion of an equivalent stability or inevitableness. The emotions aroused may be very variable with different states of the subject, or there may be no emotion at all. And hence we speak as though the emotion were a manifestation of the mind, whereas the yellow stripes, etc., are manifestations of the object. Their basis in experience is all the same; they are equally empirical events; they are equally cerebral neuroses. It is the fact that the one enters into close associations while the other does not, that causes us to rank them respectively as objective and subjective. Emotions in general are readily dissociable, and in this respect differ profoundly from the sense-impressions, which in strict psychological language are alone called sensations.

It is thus that we arrive at the distinction between mind or spirit and matter. The former is the free and unattached portion of experience; the latter is the associated or clotted portion. The former is the basis from which experience commences; the latter is the product of knowledge or acquirement. When sensations which are habitually in association with other sensations occur without their customary correlates, we get the idea of a ghost. If, for instance, the visual sensation of a human form occurs, and no corresponding sensation of resistance or solidity can be obtained, the primary impulse is to affirm that we are in the presence of a spirit. Or if certain visual sensations of colour, etc., suggesting a table or a man, are not associated with the sensation of opacity, which has previously invariably accompanied them, we again get the stock conception of a ghost: a form suggesting materiality, but a transparency which is never found with that particular class of material object. Further, when sounds, as of chains rattling, emanate from a spot where no visual impressions are experienced, we again affirm that a spirit is in evidence. For sounds are exclusively associated in experience with material objects, giving visual and tactual impressions. Where sounds occur without any of the usual correlated sensations, spirituality is immediately alleged. That is to say, as soon as the elements composing a clot of sensations or a material object are broken up and appear independently, they are affirmed to be psychical. Materiality is wholly a product of association.

We now approach the most difficult part of our subject, and that which will be most puzzling to the lay mind: the relation of body to mind, or, in our new terminology, the relation of the system of associated sensations to the reservoir of free sensations from which that system developed. Among the material objects which after some months of life form a part of the baby's experience, one begins to stand out as being unusually ubiquitous. Whereas other material objects come and go, there is one from which experience is never altogether free for long. Moreover, this particular object exhibits changes that run in a curiously parallel manner with the general series of sensations. In short, it begins to be discovered that every sensation of any kind seems to entail some activity in the object noted. The object mimics the sequences of the sensations. For every alteration of sensation experienced there appears to take place some corresponding alteration in the relation of the parts of the object in question. As in the case of other objects, this one becomes associated with a name in the course of education, and the child learns to know *its own body*, as being an object more nearly allied to the sensational stream, more accurately reflecting its changes, than any other object.

The discovery of the body opens the way to a new series of material associations. Hitherto a sensation had only called up the other sensations with which it had been immediately or objectively associated. But now it may call up those just as before, or, on the other hand, it may call up the sensations of correlated processes in that exceptionally ubiquitous clot now under discussion. The visual sensation which previously gave rise to the sensations of hardness, etc., in a table, may now give rise to the same sensations, or it may give rise to sensations of the bodily changes, ocular adjustment, etc., which run parallel to the original sensation. In short, to every experience there are now two routes of possible association. Every sensation has a dual attachment: on the one hand, with the other sensations experienced in contiguity with it, on the other hand, with the particular clot which now begins to stand out vividly from the rest. These associations are what we know as objective and subjective, and the clot in question comes to be designated by the pronoun "I."

The learning of science quickly brings more information as to the nature of the body, that is to say, adds to the number of the associations which that particular clot represents. Speaking of it now in our ordinary materialistic language, it is found, firstly, that sensation is not a product of the body as a whole, but of the nervous system, and secondly, that it is not a product of the nervous system as a whole, but of certain parts of the cerebral cortex. It is found that every kind of sensation is invariably accompanied by certain physico-chemical processes, still not understood, in a limited portion of the cerebral cortex, and the question arises as to the relation of these processes to the sensations themselves which accompany them.

From our present point of view, the question begins to resolve itself. Supposing physiology had reached a point at which it could say that the sensation of redness, for instance, is associated with such and such physico-chemical processes taking place in such and such neural cells, then we should know as much about the sensation as was possible on the subjective side. On the objective side, we know about the colour red all that physics has to tell us—that it consists of æthereal waves of specific length, and so on. By saying that, we mean that the sensation of redness has been by scientific exploration indissolubly associated in educated experience with the sensations imagined from undulations of the æther. In a sense we may affirm that the red colour *is* the undulations of named wave-length.

So on the subjective side, physiology ends by establishing an indissoluble association in educated experience between the sensation of redness and the sensations derived from witnessing some specific neural activity. In the same sense as before, it would even be correct to affirm that the sensation of redness *is* the neural activity in question. But it is probably advisable to avoid the use of words expressing identity, on account of the verbal ambiguity which is carried by all such words. The facts before us are these: (1) a sensation of redness, supposed to be primary; (2) the sensations which would be derived from æthereal undulations of specific wave-length, could they be magnified or otherwise rendered perceptible; (3) the sensations which would be derived from a specific type of neural activity taking place in specific cells, could such neural activity be rendered perceptible. The relation of (1) to (2) is the same as the relation of (1) to (3). The physicist affirms that the redness is indissolubly united with certain physical events, and he may even say that the one *is* the other. The physiologist affirms that redness is indissolubly united with certain neural events, and he too may affirm that the one is the other. But in either case, the sum-total of our knowledge is that certain sensations are associated with one another to a known extent.

In so far as the exposition has proceeded in the course of the present chapter, we appear to have reached a position of absolute idealism, in contrast to the materialism yielded by the studies of the various sciences in previous chapters. It is nevertheless a position entirely compatible with materialism in its most extreme forms. The fallacy which almost universally follows in the wake of idealism consists in supposing that that doctrine denies the reality of matter, or expresses matter in terms of mind. Let me repeat again, therefore, that the doctrine which I have adumbrated, if rightly understood, does not in the slightest degree diminish a belief in the reality of matter; and that any one who holds this doctrine is committed to the view that matter is just the hard, resistant, solid reality that it appears to be to the the most abandoned upholder of "common-sense." All I have said is that matter is a certain kind of experience, and this no one denies—that the hardness, resistance, solidity, are the elements of the experience. But in saying that matter is experience, and its qualities the elementary units of the experience, I am infinitely distant from affirming that it is unreal. Since the experience is real, the matter is also real. I have not done as is commonly done by idealists—I have not expressed matter in terms of mind, for that, indeed, would imply that the qualities of matter are psychical images, caused by some external reality of unknowable character. That is a spiritualistic doctrine, to which I am utterly opposed. So far from my beliefs is that view that I am now about to deny altogether the existence of any psychical entity to be called mind, apart from the neural processes which are supposed to accompany the workings of that entity. I am about to argue that the only possible meaning to be given to the name "mind" is the sum-total of those material neural processes, and that they are not accompanied by a shadowy entity, meaningless and powerless, as assumed in current physiological discussions.

We reached the conclusion in a previous chapter that the bodily organism is a complex machine. We found that all its processes and activities are attributable to physico-chemical forces, identical with those which are recognized in the inorganic realm. We learnt that there is no "vital force" or other spiritual interference with the normal physical sequences. If, then, there be a mind, it is reduced to the function of inertly and uselessly accompanying the activities of certain neural elements. This is the doctrine of epiphenomenalism, and it is the last word possible to one who accepts the duality of mind and matter. It is a theory which on the face of it is devoid of verisimilitude. What can be the use of such a shadowy and inefficient entity? What parallel can be found in Nature for the existence of so gratuitous a superfluity? Moreover, what mechanism, conceivable or inconceivable, could cause it thus to shadow neural processes, which *ex hypothesi* do not produce it? If one such mental state is the cause of the next, how does it happen that it causes the one which is necessary to accompany the actual neural process at the moment? Epiphenomenalism involves us in a pre-established harmony that is profoundly opposed to the scientific spirit of the twentieth century. The problem, however, is not one that need be discussed on the grounds of *a priori* probability. It is a theory that may be rigidly refuted, and to that task I now turn.

It is a part of the doctrine of epiphenomenalism that a man would to all external appearance be precisely the same whether he was possessed of his epiphenomenal mind or not. Conduct, action, expression, would not in the slightest extent be affected were he completely devoid of mind and consciousness; for all these things depend upon material sequences alone. Men are puppets or automata, and we have no further grounds for supposing them to have minds than the fact that we know we have a mind ourselves, and the argument by analogy from ourselves to them. But arguments from analogy are notoriously insecure, and it seems, therefore, to be quite within the bounds of possibility to the epiphenomenalist that some or all other men may be mindless syntheses of matter. Descartes did, indeed, affirm this very thing of lower animals.

Now let us assume that such a man actually exists, or, if you prefer, let us assume that physical chemistry has advanced to such a pitch that a man may be synthetized in the laboratory, starting from the elements, carbon, nitrogen, etc., of which protoplasm is composed. Let us assume in any case a "synthetic man" without a mind, yet indistinguishable by the epiphenomenalist hypothesis from another man identically constituted materially but having a mind. Ask the synthetic man whether he has a mind. What will he say? Inevitably he will say yes. For he must say the same thing as the man, identically made, who *has* a mind. Otherwise the same question would set up different responses in the nervous systems of the two, and that is by hypothesis impossible. The sound of the words "have you a mind?" entering the ears of the synthetic man sets up highly complex cerebral associations (which we call grasping their meaning); these associations will, after a short time, culminate in nervous currents to the tongue, lips and larynx, which will be moved in such a way as to produce an audible and intelligent answer. Now this answer must be the same in the case of the man who has a mind as in the case of the mindless man, since their nervous systems are the same. If there was a different vocal response to an identical aural stimulus, then there must in one of them have been some external interference with the physico-chemical sequences. Mind must have broken through the chain of physical causality, and that is contrary to hypothesis.

What can the epiphenomenalist say? That the mindless man is a liar, to say he has a mind? That will not do, for if the two men are objectively identical one cannot be a liar, and the other not; one engaged in deceit, while the other speaks the truth. The epiphenomenalist is thrown back, therefore, on the assumption that the mindless man has made a mistake; that he thinks he has a mind, but really has not one; that his nervous constitution is such as to impel him to the conviction that he has a mind when he really has not, to lead him to talk upon psychical phenomena and their differences from matter, and in general to behave exactly as if he knew all about mind and matter, had considered the subject of their relationship, etc.

The example shows, furthermore, that the condition of "knowing one has a mind" is a condition which can be stated and accounted for in rigidly materialistic terms. When the epiphenomenalist himself asserts that he has a mind, the movements of his vocal cords by which he makes that pronouncement are by his own theory led up to by a chain of purely material sequences. He would make just the same pronouncement if he had no mind at all. His claim to possess a mind, therefore, is wholly irrelevant to the real question whether he actually has a mind or not. The events that make him say he has a mind are not the actual possession of a mind, but those cerebral processes which, in epiphenomenalist language, are said to underlie states of consciousness. It is the cerebral processes alone which make him speak, and his utterance, his belief in a mind, furnish testimony alone to the existence of those cerebral processes. Were the mind truly able to compel a belief and an announcement of its own existence, it could only be by breaking through the chain of material bodily sequences, and this is a vitalistic supposition that is ruled out by physiology. The belief in the possession of a mind is a cerebral condition, due, not to the actual possession of a mind, but to definite pre-existing cerebral conditions on the same material plane.

I do not see how epiphenomenalism could be much more effectively refuted. Yet it is the only respectable dualistic theory that is compatible with physiological mechanism. Let me recapitulate for a moment the facts, now before us, upon which we have to establish a theory of the relationship of mind and body.

Physiology has shown that bodily activity of every kind is a product of purely material sequences, into the course of which there is no irruption of any spiritualistic factor. On the dualistic theory, that doctrine is excessively difficult to understand. You move your arm by an act of will, or what seems to be a non-material cause, and yet it is conclusively established that the movement of the arm is due to definite material changes occurring in the brain, and caused by the fixed laws of physics and chemistry in the most determinist fashion. Now, anchoring ourselves firmly to that fact, we are confronted with the problem of where to put the mind. For every mental state there is some corresponding cerebral state; the one appears to be the exact counterpart of the other down to the smallest discoverable particular. Now on the dualistic assumption, there is only one possible hypothesis, namely, that of epiphenomenalism. Or, rather, it is incorrect to call it an hypothesis; for *if* there are two things, mind and body, epiphenomenalism is no more than a statement of the facts established by physiology and psychology. Dualistic physiologists, therefore, are practically forced to accept it. Yet, as I have shown, it is utterly untenable when properly thought out.

We are faced, therefore, by two possible alternatives: (1) to abandon mechanism, (2) to abandon dualism. Now mechanism is a physiological theory which is proved. We must hold fast to it therefore at any expense to our metaphysical preconceptions. The only remaining alternative, then, is the abandonment of dualism. We must affirm that there is no thin shadow accompanying cerebral processes as alleged; that there are *not* two things, mind and body, fundamentally distinct. We must, in short, affirm that the mind *is* the cerebral processes themselves, not an imaginary accompaniment of them: and this, it will be noticed, is precisely the conclusion at which we arrived by different arguments in an earlier part of the present chapter. When we recollect that matter is but one form of experience, while mental manifestations are another similar form; when we recollect that elementary experiences may be associated into larger groups, we shall scarcely have greater difficulty in understanding how a sensation can be identified with a cerebral process than we have in understanding how, for instance, redness and hardness can be identified as properties of one material object.

I have said that mind is not an independent existence, but that it is a name for the sum-total of certain kinds of nervous or cerebral processes, and that it is therefore to be identified with phenomena of a material order. The difficulty of grasping this proposition will be very largely mitigated by the fact that there exists a phenomenon from the inorganic world which furnishes a remarkably true and precise analogy to this strange product of the organic world. The phenomenon to which I refer is the phenomenon of fire. In very early Greek philosophy, the Universe was believed to consist of earth, air, fire, and water. Fire was held to be a distinct entity on a par with the other three. We now know that it is not itself an entity of any kind, but is a manifestation of a certain chemical process, as for instance, the oxidation of carbon, in the course of which the carbon particles give forth light and heat. There is nothing whatever present in a flame except these molecules undergoing chemical change; yet, to an uneducated eye, the flame seems to be a distinct entity, differing altogether from a mere collection of chemically active material particles.

We may interpret the existence of mind in a precisely analogous manner. All that really exists is the material particles of the substance of the nervous system. When these particles enter upon a certain kind of chemical activity, the effect is to suggest the existence of some new kind of elusive non-material entity called mind. But this entity has no more real existence than has fire. In each case we have to do exclusively with molecules undergoing disintegration or combination. This chemical activity suffices in itself to account for the whole of the phenomena flowing from the centre of activity, and the belief in any additional independent entity is a fallacy which itself can be expressed and explained in physico-chemical terms. The flames of a fire flash out swiftly in all directions and vanish again, to reappear instantly in a closely similar form. So, too, the ideation or emotion of the individual may open up new avenues of mind for a brief moment, as they travel on to a new position. In each case the fluctuations of form are due to the constantly changing area of chemical activity; and just as the fire maintains for short periods a relative constancy of size and shape, so the mental content of an individual is apt to remain for a time at about the same value of intensity, and fastened to the same subjects of attention. At times the fire burns low; at other times it bursts forth into exuberant activity. The accuracy of the analogy is due to the fact that both phenomena are based upon the same foundation; the one is a manifestation from inorganic matter, while the other is a manifestation from organic matter, and therefore immeasurably more complex as to its chemistry.

When once we have got over the shock which monism carries to those accustomed to think in dualistic terms, we find that the great majority of the difficulties of metaphysics fall away. By an act of will I raise my arm. The plain man insists that his will did it; the physiologist knows that it was physico-chemical processes in the brain. The dilemma is at once overcome when the philosopher points out that the will *is* the physico-chemical processes, and that they both mean the same thing. The whole controversy of free-will and determinism is resolved by the discovery that each side means exactly the same thing, the only difference being in the terms used. The difficulty of the epiphenomenalist is also solved. He says he has a mind. What makes him say so is not a transcendental "knowledge of having mind," but a certain cerebral state. When we have affirmed the absolute identity of that knowledge with that cerebral state, all difficulties vanish. The mind is the sum-total of cerebral conditions. He says he has a mind; it is the existence of the cerebral conditions which cause him to say so. He says he has a mind because he has cerebral conditions, and his remark is true and intelligible only on the one hypothesis that the mind *is* the cerebral conditions.

A further difficulty that is abolished by monism is that of the unity and personality of mind. We feel that our consciousness is not made up merely of a succession of discrete elements, but that these are bound together as properties of a single entity, mind or soul. This unity of consciousness finds its exact parallel in the unity of the nervous system. I have already pointed out that neural activity tends at any moment to be focussed at some particular part of the nervous system. The focus of activity may travel from one part to another of the nervous system, but activity does not normally extend over any large portion of the nervous system at any one moment. The region of the nervous system momentarily illuminated by functional activity corresponds to the state of consciousness momentarily experienced. And just as the focus of activity can travel freely from one part of the nervous system to another, but can never travel *outside* the nervous system, so states ot consciousness can follow one another within the limits of the mind, and no state of consciousness can be experienced which is not a part of the personal and individual mind.

Monism again resolves the great biological difficulty as to the origin of consciousness. The biological conclusions as to the origin of life are to the effect that living and organic matter was developed by evolution from non-living and inorganic matter. The evolution of Man from unicellular parentage is a fact. There is little or no reason to doubt that his unicellular ancestor was evolved just as gradually from inorganic matter. Now, says the dualist, we know that the man has a mind. It follows, therefore, either that inorganic matter has a psychical accompaniment, or else that, in the course of evolution, there was a sudden leap: mind was suddenly intruded at some period of Man's past history. Neither of these hypotheses is easy to entertain, or perhaps even practicable to conceive. The doctrine of monism, with its assertion that there are not two ultimate things, but one, causes the difficulty to vanish; for there is then no necessity to introduce a new entity at any period of an organism's evolution. According to our theory, a conscious state is a specific neural functioning. If there is no discontinuity in the evolution of nervous elements from inorganic matter, there is then no discontinuity in the evolution of consciousness.

We are introduced furthermore to the answers required to such questions as "Do snails feel?" There is a very common, though of course entirely groundless, superstition that cold-blooded animals have no feeling; and the question how far the lower animals have sensation is important for estimating the pain which may be inflicted upon them by various kinds of human actions. We are now in a position to answer in a general way that the amount of feeling is dependent upon the extent of the development of the nervous system. With the progress of physiological psychology, we shall, no doubt, hereafter be able to give a much more specific reply. We have up to now hardly yet grasped the fact that pain is a mode of neural functioning. We have made scarcely any progress with the question as to what mode. We entertain no doubt that pain is some entirely specific physico-chemical process. When we know the exact nature of that process, and when we know also the exact physico-chemical constitution of an animal, we shall then be able to say from observation exactly how much pain it is susceptible of feeling, and how much it is actually feeling at any given moment. In visualizing the physico-chemical processes at work, we shall be visualizing the very pain itself. Let me repeat even once again the argument by which so apparently incongruous a doctrine is not only conceivable, but the only conceivable way in which the facts can be interpreted.

In the course of our manifold experiences, one, and unfortunately a common one, is that of pain. As in the developing mind association begins to bind together the elements of experience, we arrive at the conception of matter, or, rather, at matter itself. Physics adds constantly new elements to the associated group. That green box which I see before me consists, according to the physicist, of a vast aggregate of discrete molecules, undergoing vibration. Each molecule similarly consists of a little group of atoms, also vibrating. The atoms in turn are divisible into yet smaller units. Now the green box which I behold has, on the face of it, nothing in common with the sensations which would appear proper to a vast army of isolated particles. The one is continuous, the other discontinuous; the one is motionless, the other is in rapid motion throughout its parts, etc. Yet the sensation yielded by the one is now associated with the potential sensations derivable from the other, so that we say, in perfect confidence, that the one *is* the other. In just the same way there seems to be no similarity between the sensation of pain and the sensations derived from observation, actual or potential, of the physico-chemical processes which occur in nerve-cells. Yet the two are associated so closely and invariably, that we are compelled to affirm in the same way that the one *is* the other.

The question, then, as to how low in the animal scale feeling is experienced, is resolved into the more intelligible question as to how low in the animal scale do the physico-chemical processes take place which we identify as feeling. That question can only be definitely answered when it is definitely known what exactly those physico-chemical processes are. But, in the meantime, it may be permissible to speculate; and the most attractive speculation certainly seems to be that feeling is contemporaneous with organization; that the physico-chemical processes, though reaching their highest activity in the nervous systems, are processes which occur in a more primitive manner in undifferentiated protoplasm itself.

We may, for a moment, profitably compare the philosophical result which we have reached with the structure of the nervous system. We have built up the whole of mental life from elementary sensations, which are susceptible of becoming associated more or less closely together. Sensations are the only fundamental reality, so far as we are concerned, and association is the only fundamental process. All abstract ideas, such as that of "existence," are compounded of sensations related to one another by more or less close degrees of association. In general, for instance, "existence" is a property of an object connoting the liability to raise certain sensations under certain conditions. It is resolved ultimately into an anticipation of possible visual, tactual or other sensations; and it has no meaning whatever except in so far as it may be expressed in terms of sensation. I say "in general," because the word "existence," like all words in common use, has no clearly defined limitation of meaning, but is used in many different senses. But the sense in which I have taken it is the only one that has any interest for the present discussion.

It is their failure to appreciate this circumstance that has caused so many metaphysicians to embark upon the solution of false and unreal problems, such problems as: Does matter exist? Do other men exist? Do I exist? with the singularly unsatisfactory replies of which Descartes' is a type: *cogito, ergo sum.* If a particular group of sensations contains among them the sensations connoted by existence, then that object exists (except in illusions, where the component sensations are linked in unusual associations). But there is no metaphysical problem of real existence; for the whole idea of existence is phenomenal, not noumenal, so to speak; it depends on the quality of the association between sensations. But a still more dangerous fallacy is that which deduces from idealism the non-reality of matter. Reality, like existence, is not a property of so-called "noumena"; and by merely including matter and mind under the one heading "experience," there is no more derogation from the reality, solidity, exteriority of matter, than there is from the essential qualities of mind. Matter is real, in the amplest possible sense that can be applied to the term real. It requires no underlying basis or noumenon to support its claim to reality. It is as real as anything that can be brought within our understanding. When I affirm that *Esse est percipi*, I am not diminishing the reality of *Esse* any more than, when I affirm that heat is motion, I diminish the reality of heat.

The synthesis of mind from simple elements, conjoined with one another to a varying extent, has its exact parallel in the structure of the nervous system. For the nervous system is entirely made up of central ganglionic cells on the one hand, and conducting fibres on the other hand, by which cells are kept in association with one another through synapses. We must suppose that in the theoretically primitive condition, where the sensations are entirely dissociated, the association fibres running between the cortical cells are still undeveloped, or the synapses impermeable. Stimulus to the sense-organ produces activity in the corresponding cortical cells, and that activity *is* sensation. An ocular stimulus gives rise to colour-sensations in a certain part of the brain. A tactual stimulus gives rise to pressure-sensations in another part. But there is no high-road of association between these two parts. The colour-sensation does not invoke the anticipation of tactual sensation, and there is, in consequence, no conception of matter. With progressive development the paths of association are perfected, and considerable areas of the brain come to function as independent units. This is the cerebral origin of the idea of matter. In the perception of a material object two things are involved: (1) the object itself; (2) the cerebral activity set up by stimulus by the object upon the sense-organs. The first is the associated sum of sensations, called the qualities of the object; the second is the consciousness of the object; and it is this duality of material things which represents the difference between the psychical and the physical.

We may now begin to perceive how it is that science is based upon materialism, and how materialism is the only possible working hypothesis of life. The psychological doctrine of association shows that all intellectual operations, including therein all scientific theories, proceed by bringing two previously isolated factors into relation with one another. I will take an instance which I employed in a former work. Sir Isaac Newton saw an apple fall to the ground. He had previously been reflecting on the causes which kept the planets in their orbits. The discovery of the law of gravitation took place when these two widely remote events were suddenly brought into relation with one another and perceived as illustrations of a single principle. Observation and co-ordination are the two ultimate factors of science. By observation new properties of objects are placed on record. By co-ordination they are generalized, classified and brought into relation with the previous system of knowledge. Here once more are the original elements ot mental life with which we have become so well acquainted. New sensations are brought into the arena of attention; this corresponds to observation. New associations are formed between them and other known associated sensations; this corresponds to co-ordination. The most abstruse conceptions of science are reached by precisely the same methods as those by which the conception of matter is reached in the mind of the infant. Sensations compounded are the basis of matter. A scientific theory is a statement of some immensely elaborate association, combining perhaps myriads of isolated observations. The discovery of matter is the foundation of science, and the first step made in the creation of knowledge. Sensations, originally free, begin to hang together in little groups. Here we get matter. The little groups hang together in larger groups, and we get the beginnings of science. The larger groups hang together, and we have the greatest generalizations of science. Some dream of a time when these larger groups will be compounded and re-compounded again till the whole of sensible phenomena are brought within the range of a single generalization: they dream of a total unification of knowledge.

However that may be, we reach the conclusion that science is a statement of the most complex and elaborate of the associations found to exist among the various items of experience. Matter represents the most elementary and simple of all the associations among items of experience. Thus science must of necessity rest upon matter. Its units are the little groups of sensation called material objects. The relation of science to matter is identical with the relation of algebra to the symbols x, y, z, which enter its equations. x, y, *and* z stand for some specific arithmetical quantities, just as the material object "table" stands for specific elementary sensations. Science, if removed from its material basis, and compelled to start from primitive sensation, would resemble a mathematics from which the symbols of algebra and the calculus were excluded, and which had to work in arithmetical figures alone.

The question whether there can be any science not based upon materialism, or contradictory of materialism, receives a negative answer. Science is the product of a materialistic scheme of things, and rests upon matter, as physics rests upon the conservation of energy. Nor is there anything very dreadful in this kind of materialism; for it is only a name for the way in which sensations hang together. Knowledge is association. Materialism is the name for the great scheme of associated sensations which represents all knowledge. The free, unassociated sensations or emotions which have hitherto remained outside the materialistic scheme, have at the same time remained elementary facts of which nothing whatever was known. The only hope for knowledge concerning mental states is to bring them within the scheme of materialism. That, happily, is now on the way to accomplishment. The identification of mental states with cerebral states brings them immediately within the scope of the "laws" of matter, of physics, and of physiology. The generalizations and principles established for those sciences can now be made available to furnish information concerning the coexistences and sequences among mental states. Nothing any longer remains outside materialism, which now embraces every branch of physical and psychical phenomena. Hence it is that the man of science, the physiologist, and even the psychologist, may speak as though nothing whatever existed but matter. Hence it is that mind, as apart from matter, has been banished from any share in causality or scientific explanations. Hence it is that, on the assumption of matter alone without mind, the psychologist can analyze the motives and prophesy the actions of humanity.

Such being our conclusions with regard to materialism, what is to be said of the numerous systems of philosophy and theology that have from time to time been built up? In general they attempt to explain difficulties and furnish solutions by imagining the existence of fictitious entities. In the case of religions, this statement needs no illustration. The various systems of theology proceed on the assumption that there exist a god or gods wholly immaterial in character. A ready-made explanation is thus at hand for any difficulties which occur as to relation of mind and body or any other of the problems of philosophy. It is needless to reopen the great conflict of the nineteenth century between science and religion. Little interest is now taken in the question. The vast majority of thinkers have abandoned any attempt at theological explanations. Theology has been weighed in the balance and found wanting.

But still a belief in spiritual existences of various kinds remains tolerably widespread, though much less firmly established than of old. Such a belief, for instance, is that in souls, which even now finds scientific defenders such as Dr. William McDougall. In the Middle Ages souls were regarded as scarcely less material than the bodies to which they were attached. In drawings of the twelfth century, for instance, the soul is depicted as more or less human in form. It had weight and could be balanced in scales. It was, and indeed remained till much later, liable to pain from the same physical causes, such as fire, that produce pain in material organisms. Just the same beliefs are found among primitive peoples of the present day. They leave food beside a dead man's grave for the soul to feed upon. They leave holes in the grave for the soul to come in and out, or they pile mounds over it to keep it in. In more advanced culture the materiality of the alleged soul decreases. It is identified in a vague sort of way with the breath; hence, indeed, the very name of *spirit*, from the Latin for breath. Still later it was divested further of material qualities. It long continued, however, to retain the material quality of occupying space, and numberless speculations were indulged in as to "the site of the soul."

Many other metaphysical theories proceed on similar lines. Hans Driesch, for instance, proposed to explain organic development by means of a mysterious thing called entelechy, aided by an if possible more mysterious thing called psychoid. Others invoke "biotic energy" for the same purpose. "Noumena" and "the Absolute" are favourite creations of a large and influential school of metaphysicians. In general it may be laid down that the creation of imaginary entities is a tempting method of "explanation" which is likely to continue for long to mislead the unwary.

Now it is characteristic of all these spiritual entities that they can only be conceived by attributing to them material qualities, and that as soon as they are completely deprived of all material qualities they and the belief in them promptly vanish. For, as I have so frequently repeated in the course of this chapter, beliefs, like all other mental states, are products of sensation and association. Where there is no sensation, either real or imagined, there is no belief. If a spirit has neither visibility, nor tangibility, nor divisibility, nor position in space, nor any other property whatever, it is then identical with nothing. To conceive it, or to believe in it, is to materialize it to some extent. It is imagined as having a position in space, or some vague generalized form such as the spherical, or the power to emit light or sound, or to move bodies, or some other purely material attribute. In short, spirit cannot be conceived off the material plane. The name either connotes nothing, or it connotes some material quality. The very statement that it exists is the attribution to it of a purely material characteristic. And in so far as it possesses material characteristics, it is included within the materialistic scheme of natural events.

Spiritualism, then, has to be condemned root and branch. And in so condemning it, I would include under it various other beliefs not usually associated with it. I would include, for instance, the metaphysical materialism of the ancient Greeks. For their materialism was very different from ours. They acquiesced in the existence of souls, and differed only from the spiritualists in affirming that souls were made of matter. That they were philosophically far more advanced than their spiritualistic contemporaries is true; for their materialistic outlook anticipated modern views in a very remarkable manner. But scientific materialism of the present day has kept their general point of view, while dropping their metaphysics. We agree with Democritus that if there were a second entity connected with the body, it would necessarily be a material thing; but we deny the existence of any such entity.

The question of the origin of ideas of soul, spirit, etc., has been approached both from the psychological and the sociological sides, and numerous theories have been suggested. There is no occasion here to enter upon so controversial a subject. We are concerned, not with the origin of the idea, but with the fact that the idea is a superstition. All existences of every kind form part of the materialistic scheme propounded by physics, and the assertion that there are existences outside that scheme is not even an intelligible statement: it is a sentence which carries no correlate in the realm of ideas. It is conceived only by tacitly supplying the material attributes which are verbally denied.

Criticism on this doctrine usually runs on the lines that it is a "narrow" and "unsatisfying" interpretation of

Nature; that by bringing everything within a mechanical system, we knock the very soul out of life and Nature. I am little interested to meet this criticism, which, indeed, has no reference to the subject of the present work. I have been endeavouring to show that the doctrine is true; and in so far, it is a matter of indifference to me whether it is narrow and unsatisfying or not. That is a question of altogether different character, to be argued on totally different principles. I fail to see the slightest grain of accuracy in the criticism, however. We know what life is, with its art, its morality, its beauty and ugliness, its goodness and badness. All these things are just the same in fact, whatever may be the theories which we form of them. Nature is just the same Nature, whether our theories of it are materialistic or spiritualistic; and the purpose of my theory is not to satisfy the emotions but to state the truth. There are a certain number who used to think that Man is degraded by his descent from apes. Why they should think so is a puzzle to those whose minds are philosophically orientated, for the nature of Man is exactly the same whatever our theory may be. He is just the same man, whether he is descended from apes or gods. So, too, Nature is not altered a particle by the discovery that it is organized into a materialistic scheme.

Others, again, are distressed because materialism offers them no prospect of a future life. This, again, if it is a fault, is the fault of Nature and not of the philosopher who describes Nature. But there seems nothing so very terrible about it, to one who looks at the facts calmly. The emotion of fear of death has been developed by Natural Selection; for without it no advanced species could continue to exist. Death at all events extinguishes that emotion in common with the rest. But, as it happens, we are partially dying from the day we were born. I do not allude to the fact that the matter of which our bodies are composed is continually changing, so that after a year or two we are composed of altogether different material substance; I refer more to mental changes. The mind which we possessed at the age of three is dead and gone; and at the age of seventy a man bears less resemblance to himself at three than he does to other men of seventy. The mind has radically changed, the body is entirely different; the child is effectively gone as much as if it was dead. In the words of St. Augustine: *Ecce infantia mea olim mortua est et ego vivo.* Why then do we not bemoan the spiritual death of our childhood as much, or more, than we do the anticipated death of old age? By all reasonable standards, the loss of youth is more regrettable than the loss of an old and decrepit body and mind. It is, on the whole, true that youth is spent in the pursuit of pleasure, while old age is spent in the avoidance of pain. Yet men fear far more the ultimate extinction of life than they do the onset of old age. And the reason is plain: that Natural Selection has developed an emotion in favour of continuing life at any cost, because this is necessary for the species; but it has developed no emotion of distress on the extinction of child-mind, because that emotion would be superfluous and unnecessary for the species. The subject of the desirableness of ultimate annihilation falls, however, outside the province of this book.

It remains now to summarize the conclusions of this chapter. Sensation is the only fundamental reality attainable, and the only changes which it can undergo are by association of elementary sensations or groups of sensations with one another. From sensation with association is built up our conception of the Universe. The earliest product of associated sensation is matter, which is a generalization comprising a number of separate sensations commonly associated. Later products are the theories and principles of the various sciences. Mind is a name for certain elementary and associative processes occurring in the nervous system. All the processes and events occurring in Nature fit into the scheme of materialism founded in physical and chemical laws. In other words, materialism in the sense indicated is a true philosophy. There are no existences of spiritual character differing from matter. Mind and matter are equally real, but they are not made of different stuff. Mind is neural activity; matter is associated sensation. That is to say, they are both products and types of *experience.* Hence, too, they are both equally real. There is no underlying reality more real than themselves; this is a metaphysical fancy. We reach the conclusions, therefore, of realism and materialism. But since the common acceptation of the word materialism implies a dualistic belief, together with an opposition to idealism, the theory might more correctly be styled one of Absolute Monism.

What effect is a philosophical theory likely to have on human conduct? During the early part of last century it was a favourite doctrine among philosophers that self-interest was the prime motive in the conduct of men—a doctrine reflected in most of the works of Political Economy belonging to that period. Such an opinion cannot be entertained for a moment. Men are not driven by intellect, but by passion; they are guided, not by Reason, but by Faith. The greatest upheavals of history illustrate this truth, from the time of the First Crusade down to our own great war. And it is well that this should be so. A world driven at every turn by cold calculations of personal interest might indeed bear the outward semblance of prosperity, but would be dead and soulless within. And so it is that philosophical theories in the past, where they have touched the emotions of mankind, have been more potent springs of activity than any enactments of kings or parliaments. Consider only how the philosophy of the Christian religion has for two millennia dominated the activities of mankind. Secular powers control the bodies of men; philosophic faith controls their souls. Philosophy in this large sense underlies and inspires all human effort; it lies so deep down in human nature that it often is not even seen from the surface. Yet with silent and irresistible power, it gradually asserts its absolute and all-embracing authority over humanity. For it directs their passions, and from their passions flow their actions.

We all know the evils which arise when error enters into the enactments of secular government. How inestimably more lamentable is it when error has crept into our very foundations of thought, feeling and action. Towards every problem in life our minds are orientated amiss. Nothing goes quite as it should; evils are encountered on every side; devouring dragons rise up unreasonably and cannot be slain. For the cause lies too deep to be seen; it is because we have lacked the courage and virility to extirpate error from our philosophy. Man is subjected to many hardships at the hands of Nature; but they are as nothing by comparison with those which he creates for himself by his own misdirected passions. Let us see to it then above all other things that our philosophy of life is true. Passion is the master: Faith, not Reason, will for ever regulate the conduct of mankind. The evils which we make for ourselves will only fall away under the subtle but all-embracing influence of a true Faith.

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